Fig.1

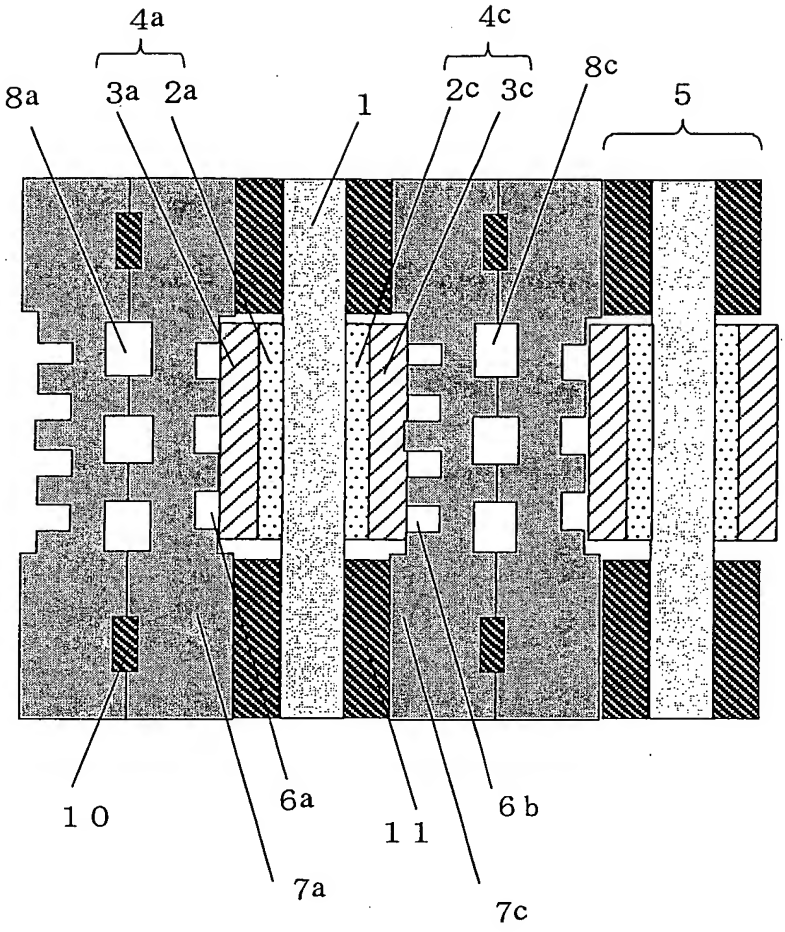


Fig.2

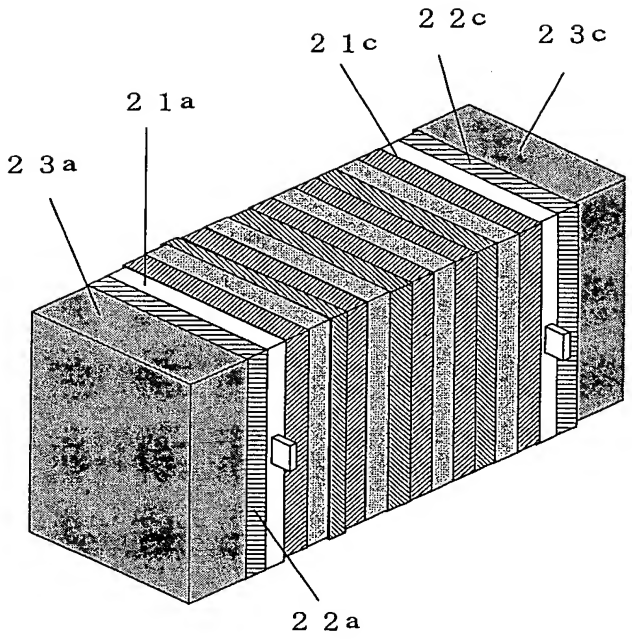


Fig.3

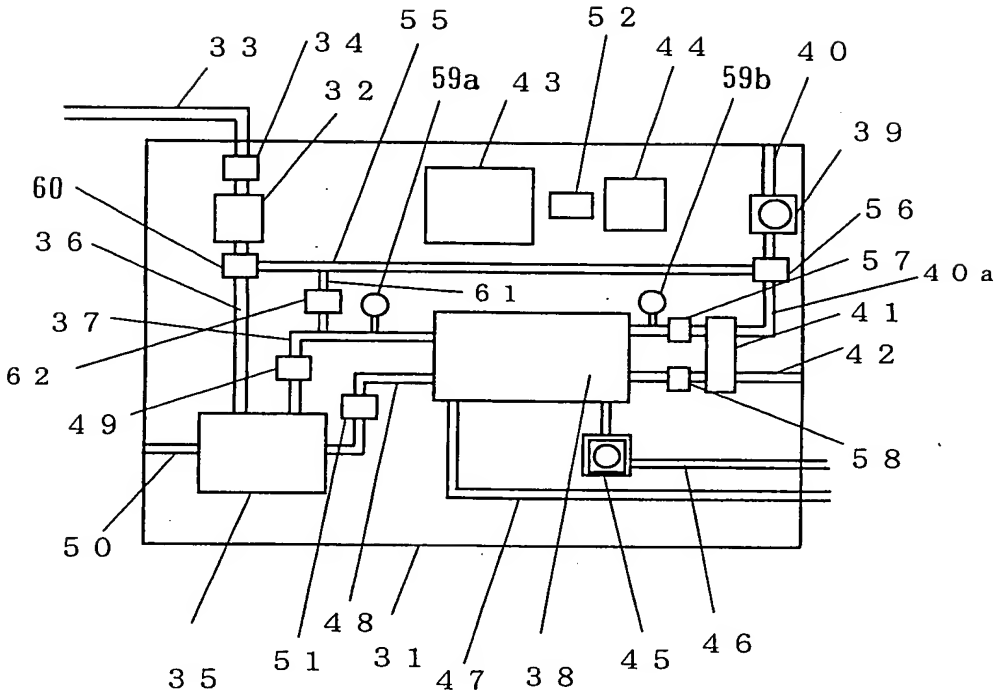

33
34
55
52
44
40
32
59a
43
59b
39
60
56
36
57
40a
61
37
41
62
42
49
58
50
35
51
48
31
47
38
45
46

Fig.4

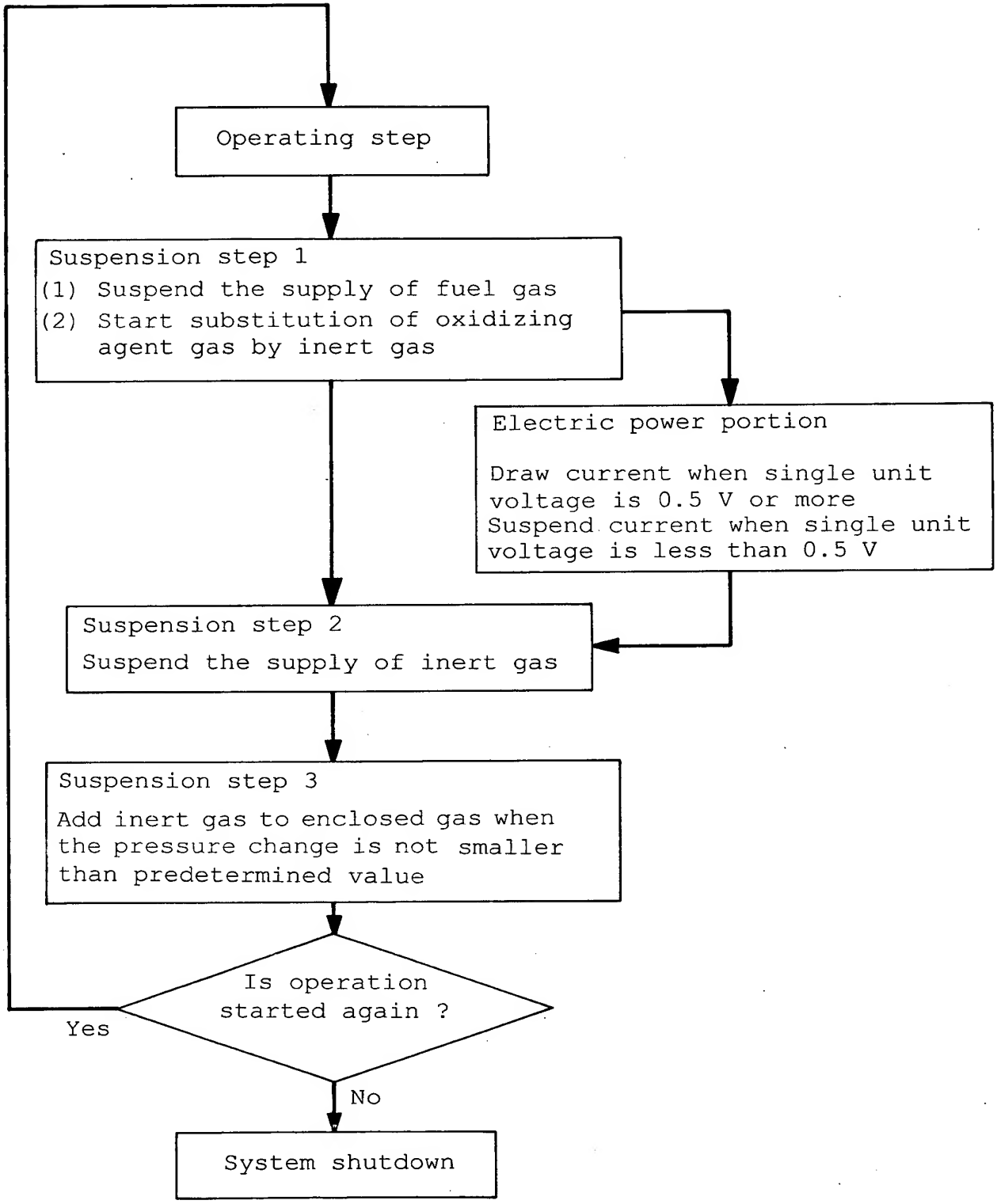

Operating step
Suspension step 1
(1) Suspend the supply of fuel gas
(2) Start substitution of oxidizing agent gas by inert gas
Electric power portion
Draw current when single unit voltage is 0.5 V or more
Suspend current when single unit voltage is less than 0.5 V
Suspension step 2
Suspend the supply of inert gas
Suspension step 3
Add inert gas to enclosed gas when the pressure change is not smaller than predetermined value
Is operation started again ?
Yes
No
System shutdown

Fig.5

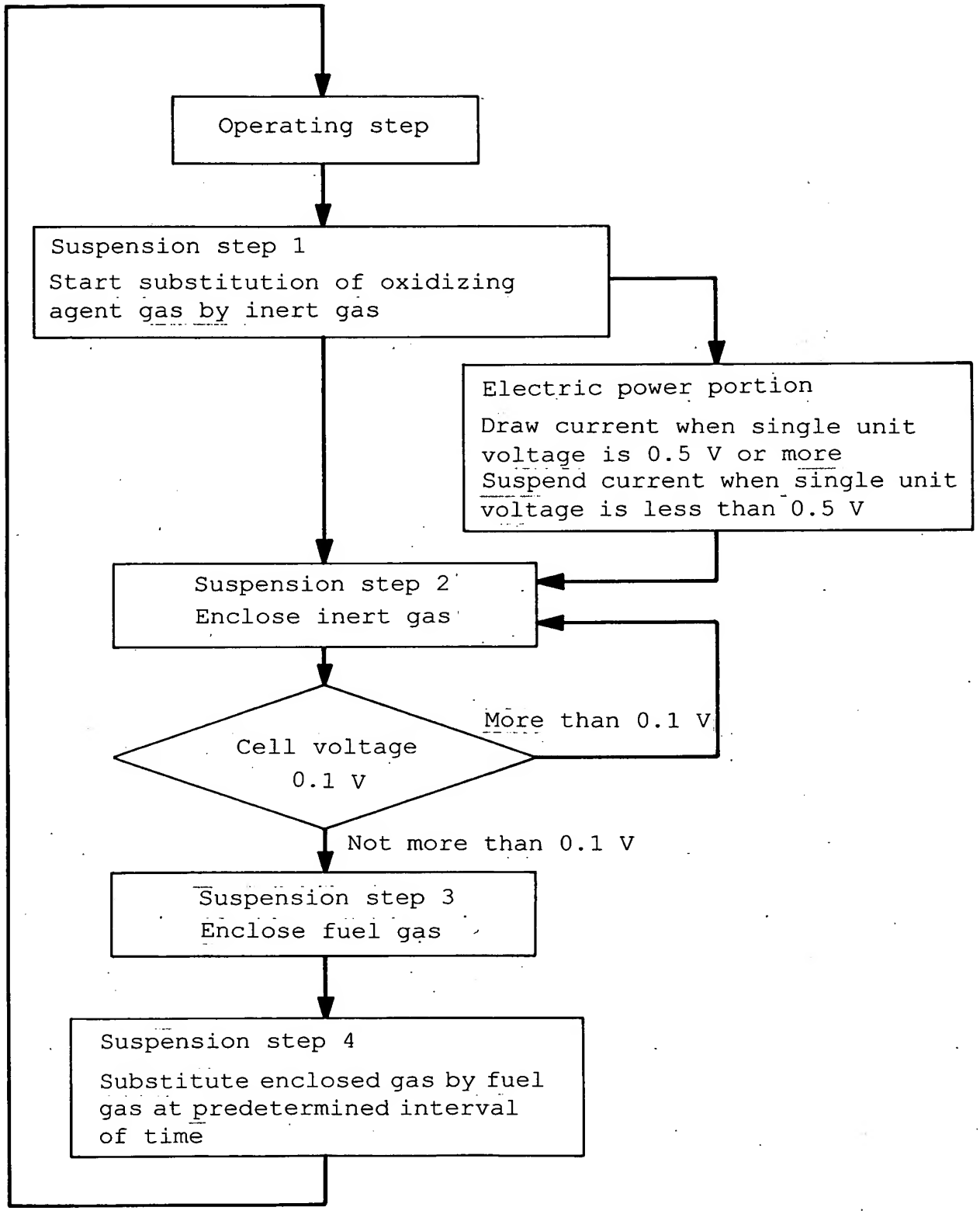

Operating step
Suspension step 1
Start substitution of oxidizing agent gas by inert gas
Electric power portion
Draw current when single unit voltage is 0.5 V or more
Suspend current when single unit voltage is less than 0.5 V
Suspension step 2
Enclose inert gas
Cell voltage
0.1 V
More than 0.1 V
Not more than 0.1 V
Suspension step 3
Enclose fuel gas
Suspension step 4
Substitute enclosed gas by fuel gas at predetermined interval of time

Fig.6

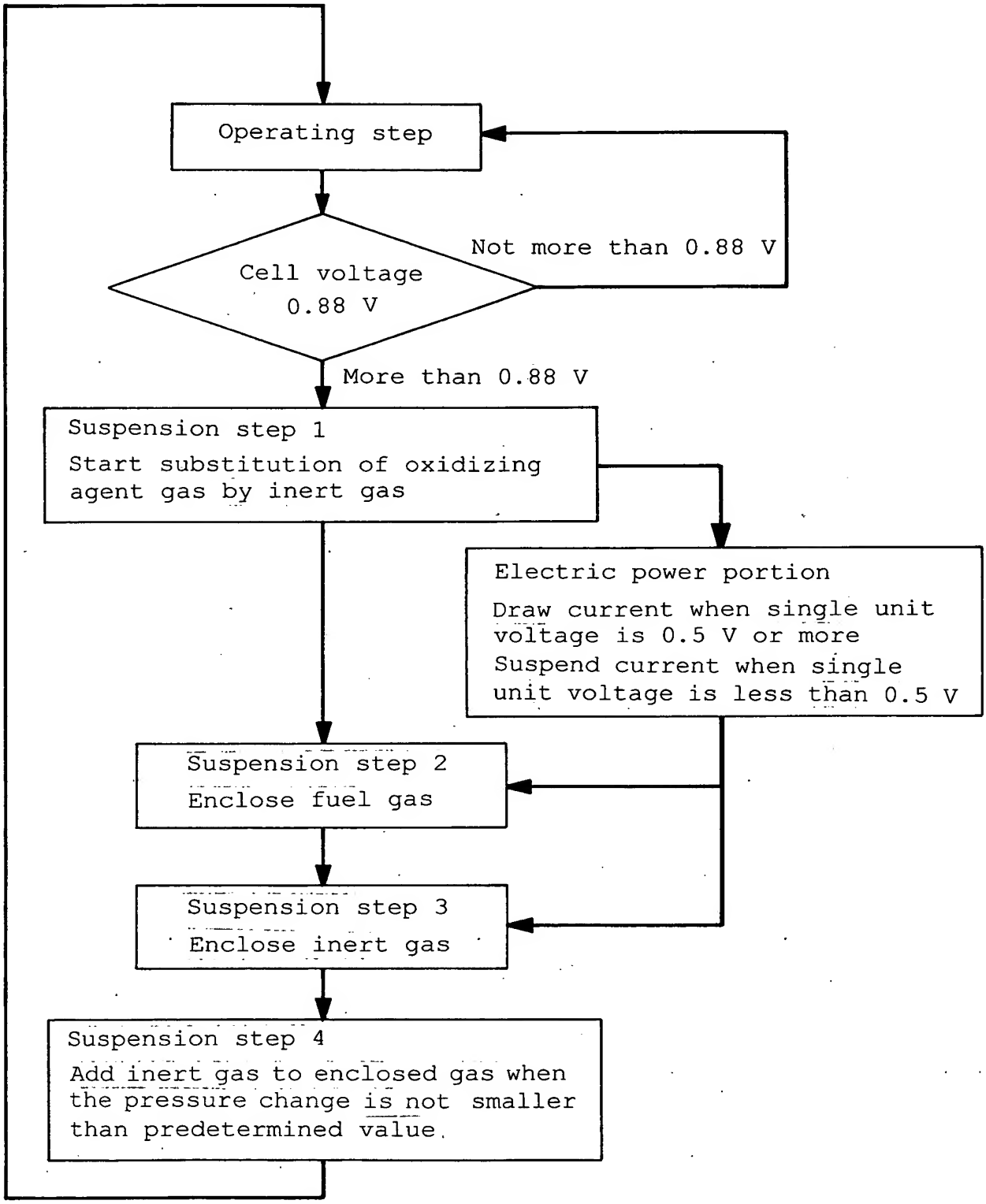
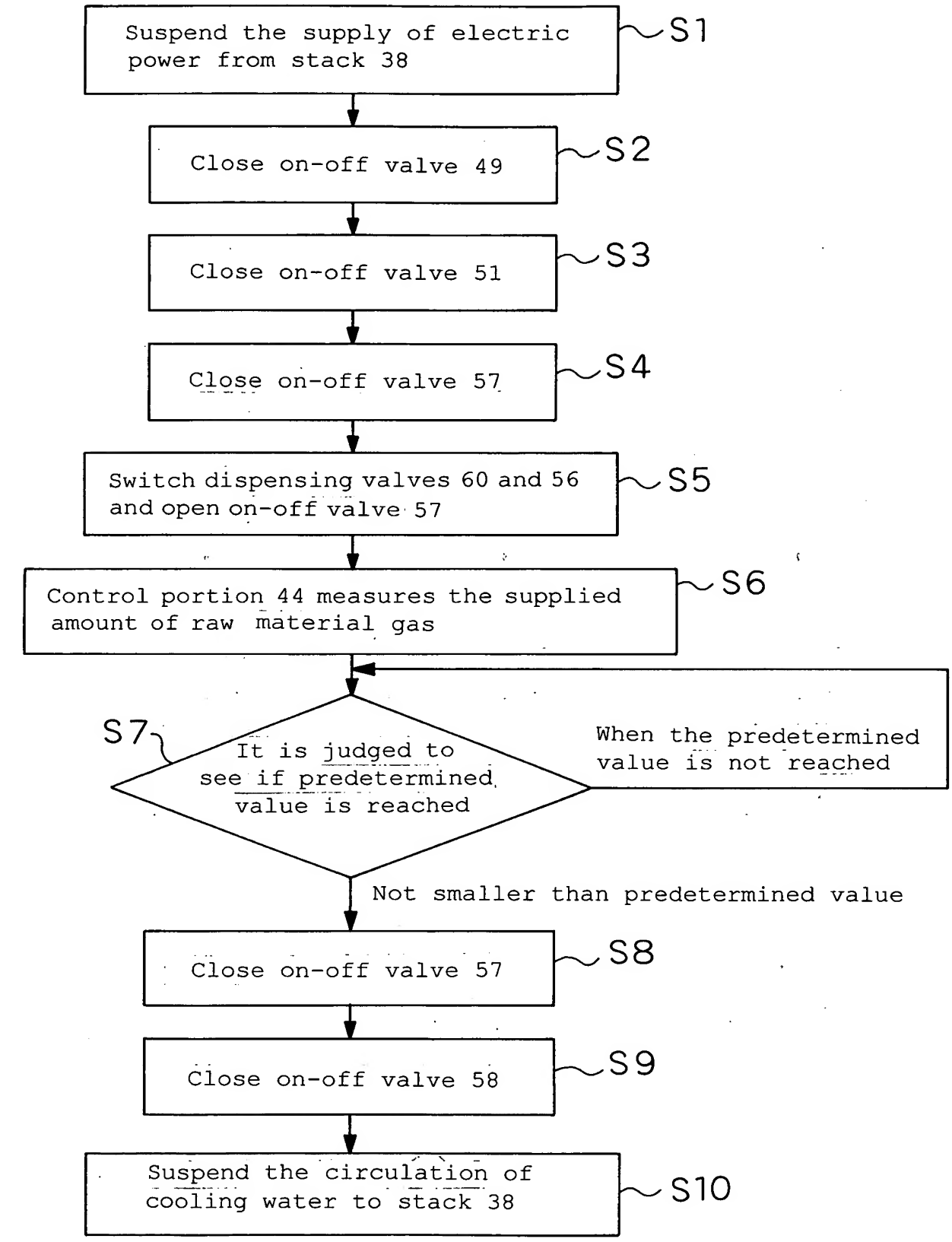

Operating step
Cell voltage
0.88 V
Not more than 0.88 V
More than 0.88 V
Suspension step 1
Start substitution of oxidizing agent gas by inert gas
Electric power portion
Draw current when single unit voltage is 0.5 V or more
Suspend current when single unit voltage is less than 0.5 V
Suspension step 2
Enclose fuel gas
Suspension step 3
Enclose inert gas
Suspension step 4
Add inert gas to enclosed gas when the pressure change is not smaller than predetermined value.

Fig.7


Suspend the supply of electric power from stack 38
S1
Close on-off valve 49
S2
Close on-off valve 51
S3
Close on-off valve 57
S4
Switch dispensing valves 60 and 56 and open on-off valve 57
S5
Control portion 44 measures the supplied amount of raw material gas
S6
S7
It is judged to see if predetermined value is reached
When the predetermined value is not reached
Not smaller than predetermined value
Close on-off valve 57
S8
Close on-off valve 58
S9
Suspend the circulation of cooling water to stack 38
S10

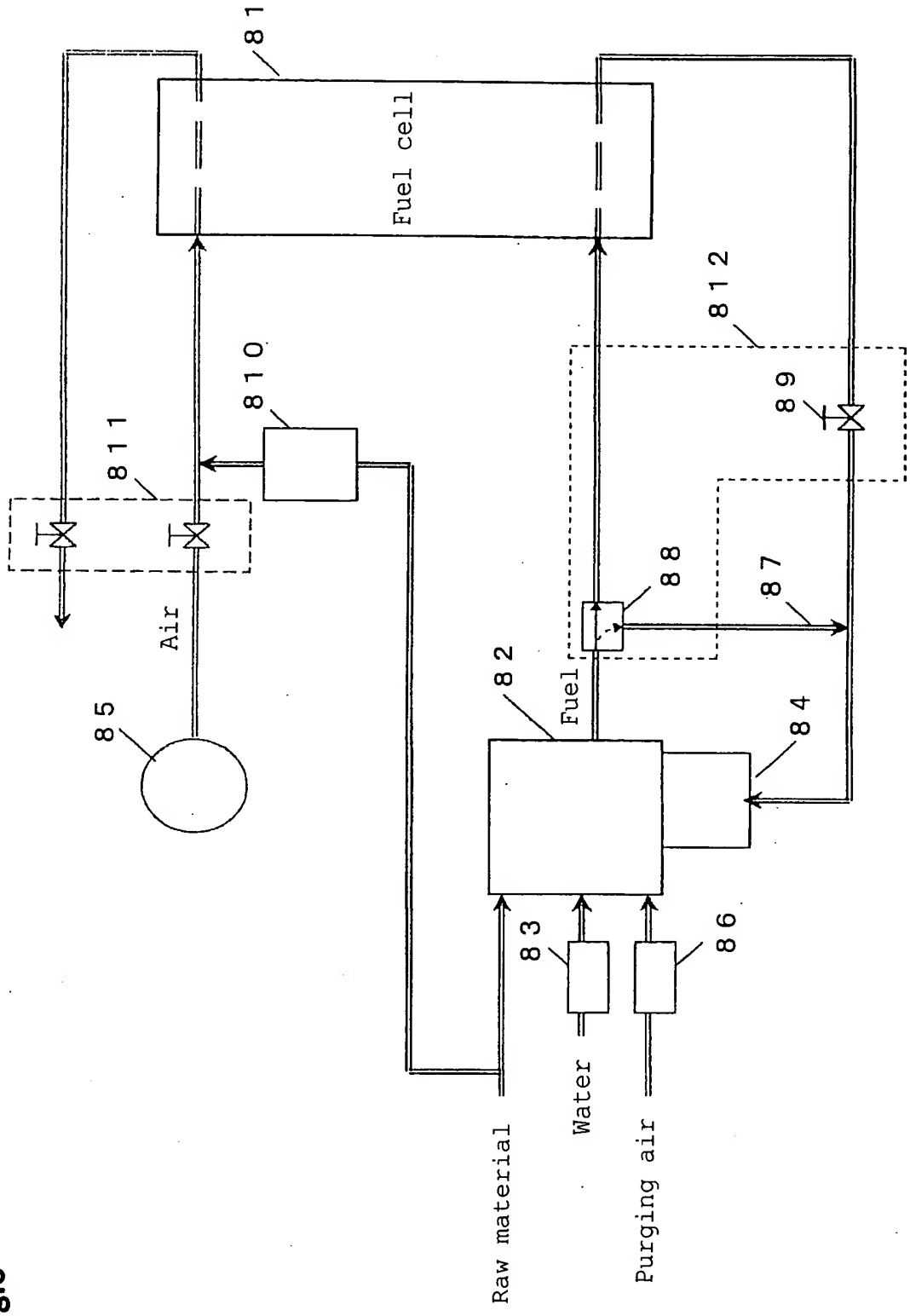

81
Fuel cell
812
810
89
811
88
87
Air
82
Fuel
85
84
83
86
Raw material
Water
Purging air

Fig.8

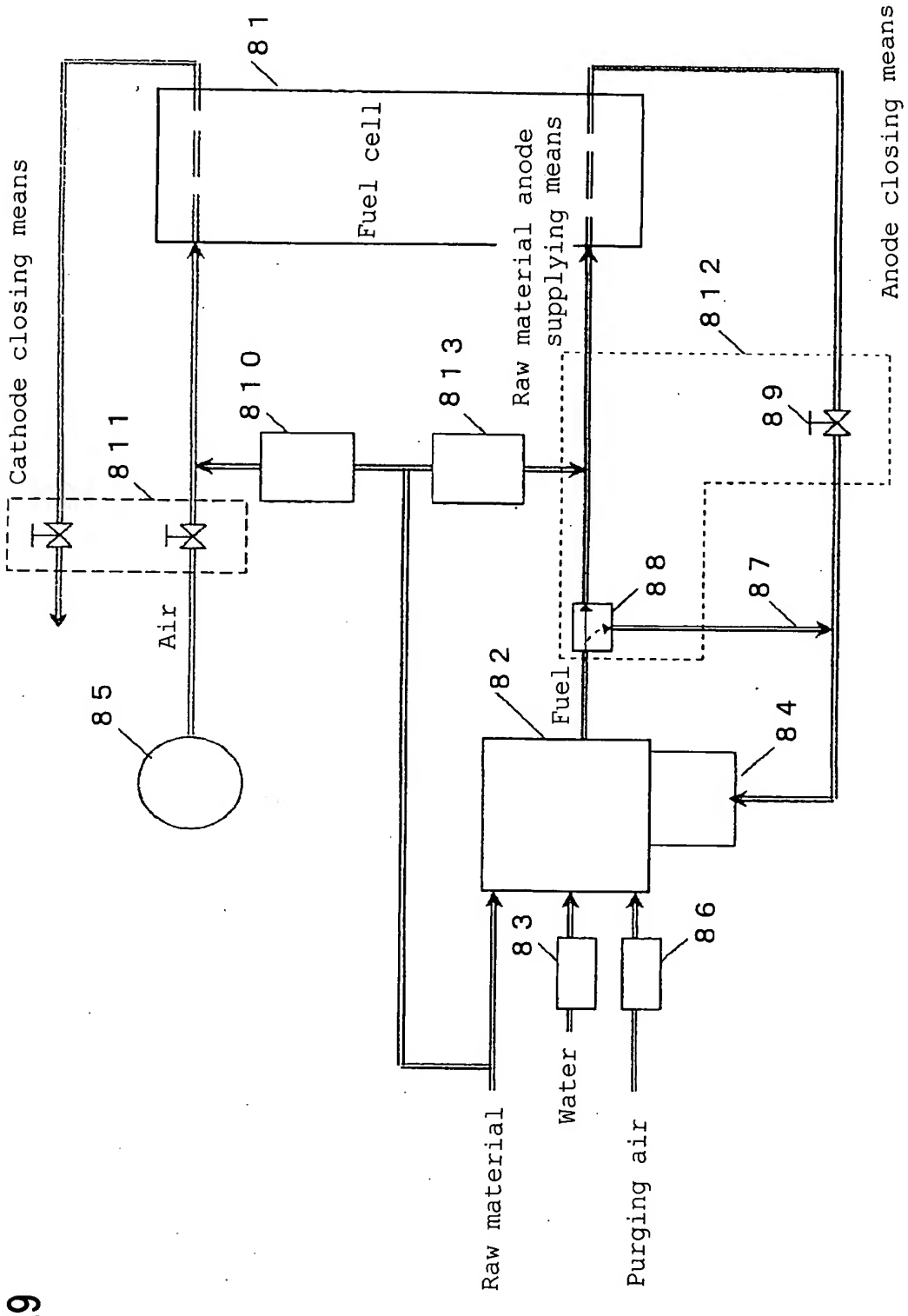
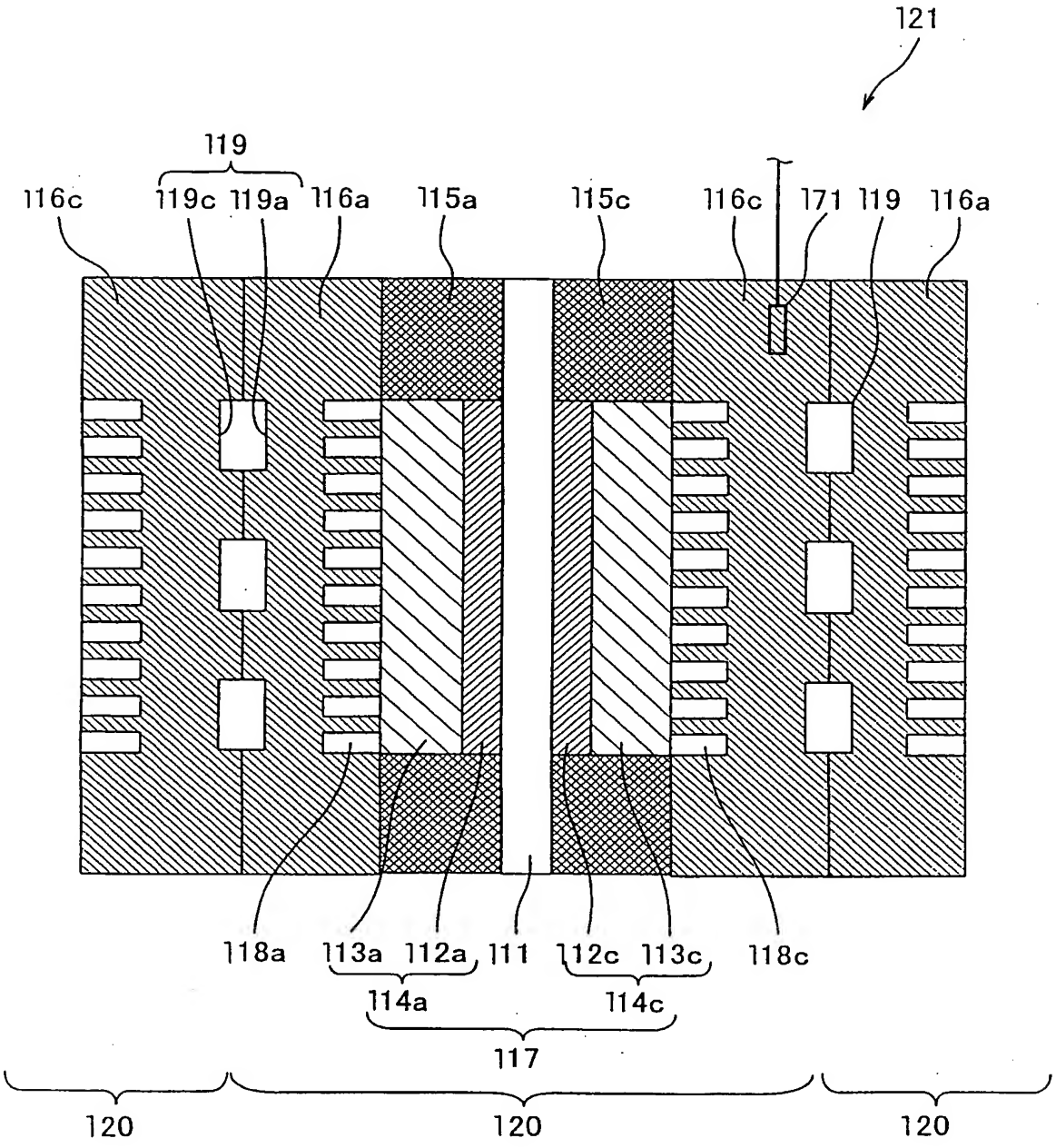

81
Fuel cell
Cathode closing means
Raw material anode supplying means
Anode closing means
811
810
813
812
89
Air
88
87
85
82
Fuel
84
83
86
Water
Purging air
Raw material
Bypassing means

Fig.9

Fig.10


121
119
116c
119c
119a
116a
115a
115c
116c
171
119
116a
118a
113a
112a
111
112c
113c
118c
114a
114c
117
120
120
120

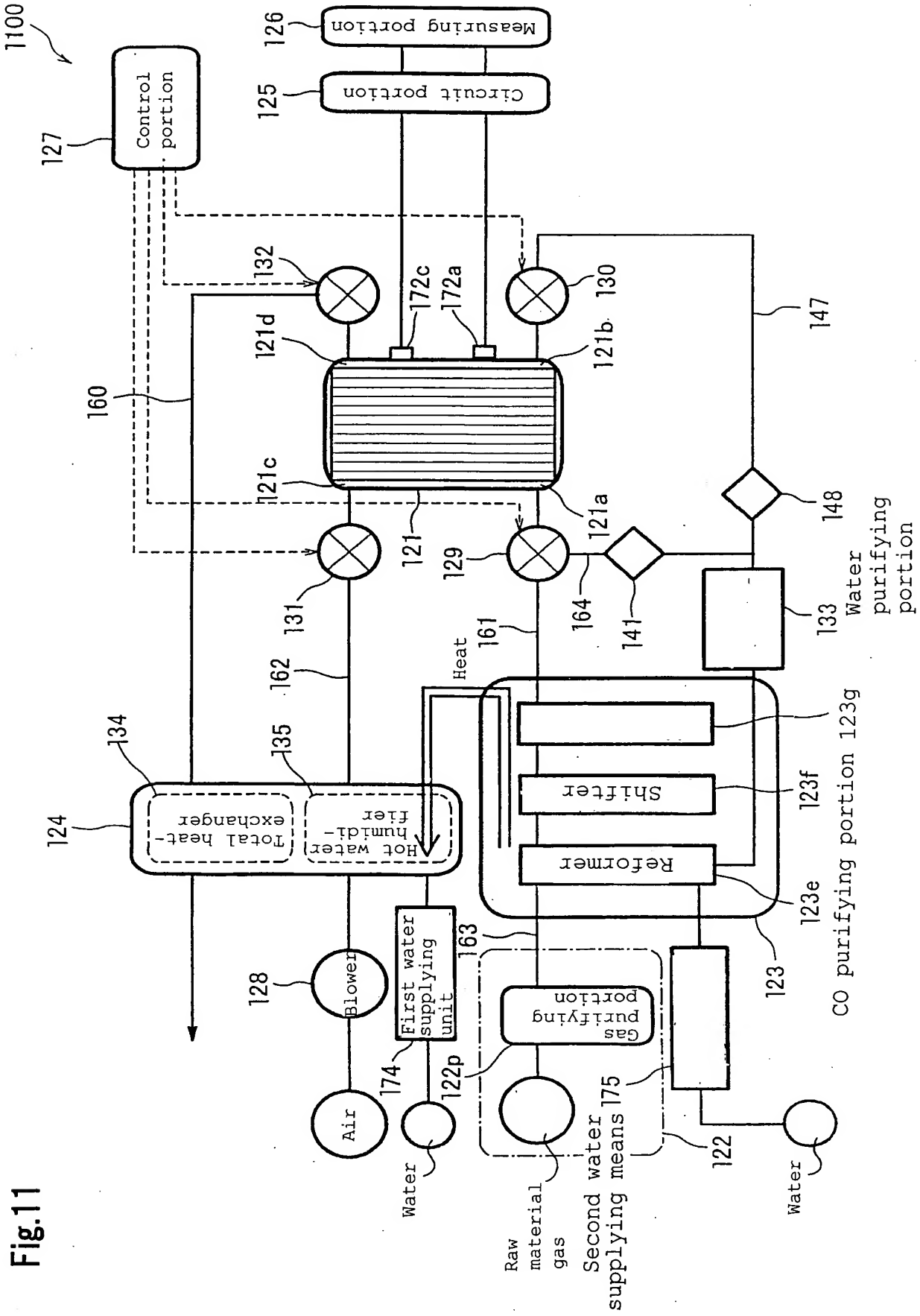

1100
Control portion
127
Measuring portion
126
Circuit portion
125
132
172c
172a
130
147
121d
121b
160
121c
121a
148
Water purifying portion
121
129
131
164
141
133
161
Heat
162
134
135
124
Total heat-exchanger
Hot water humidi-fier
Shifter
123f
Reformer
123e
123g
CO purifying portion
123
163
128
Blower
First water supplying unit
Gas purifying portion
174
122p
175
Air
Water
Raw material gas
Second water supplying means
122
Water

Fig.11

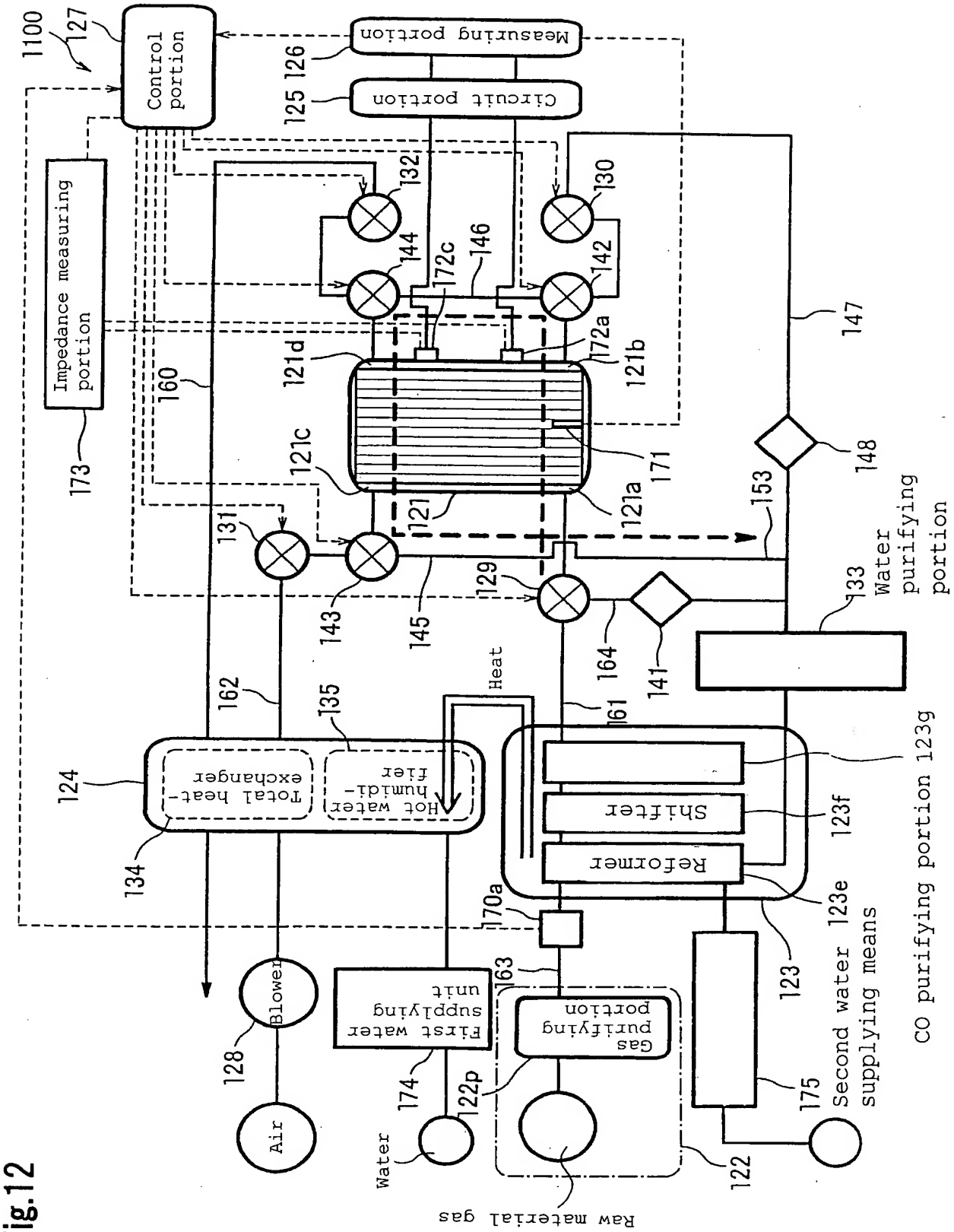

1100
127
Control portion
Measuring portion
126
125
Circuit portion
Impedance measuring portion
173
160
132
130
144
172c
146
142
172a
147
121d
121b
121c
171
121a
121
153
148
131
129
143
145
164
141
133
Water purifying portion
162
135
Heat
161
124
Total heat-exchanger
Hot water humidi-fier
134
Shifter
123f
Reformer
123e
170a
123
CO purifying portion 123g
Second water supplying means
163
Blower
First water supplying unit
Gas purifying portion
128
174
122p
175
Air
Water
Raw material gas
122

Fig.12

Fig.13

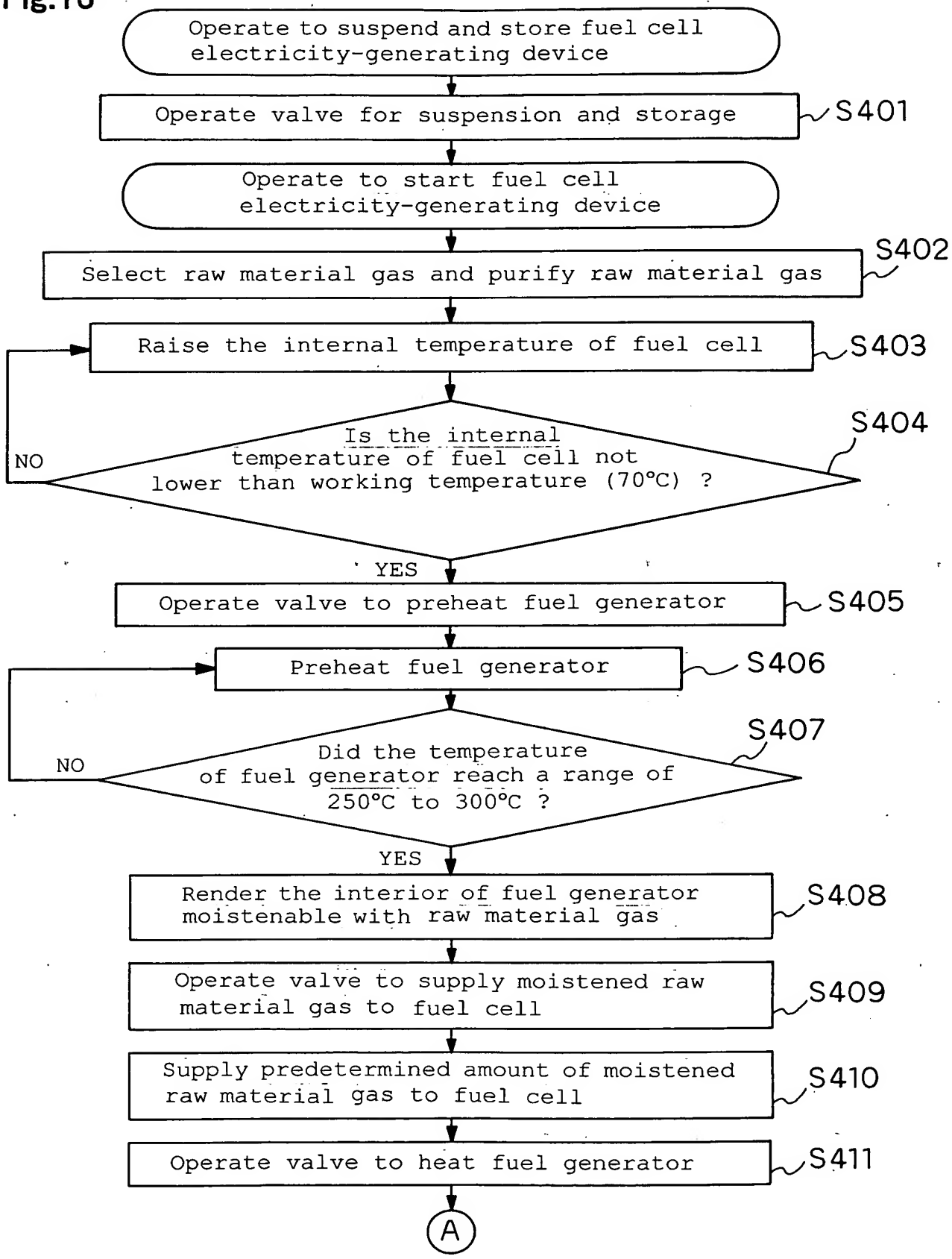
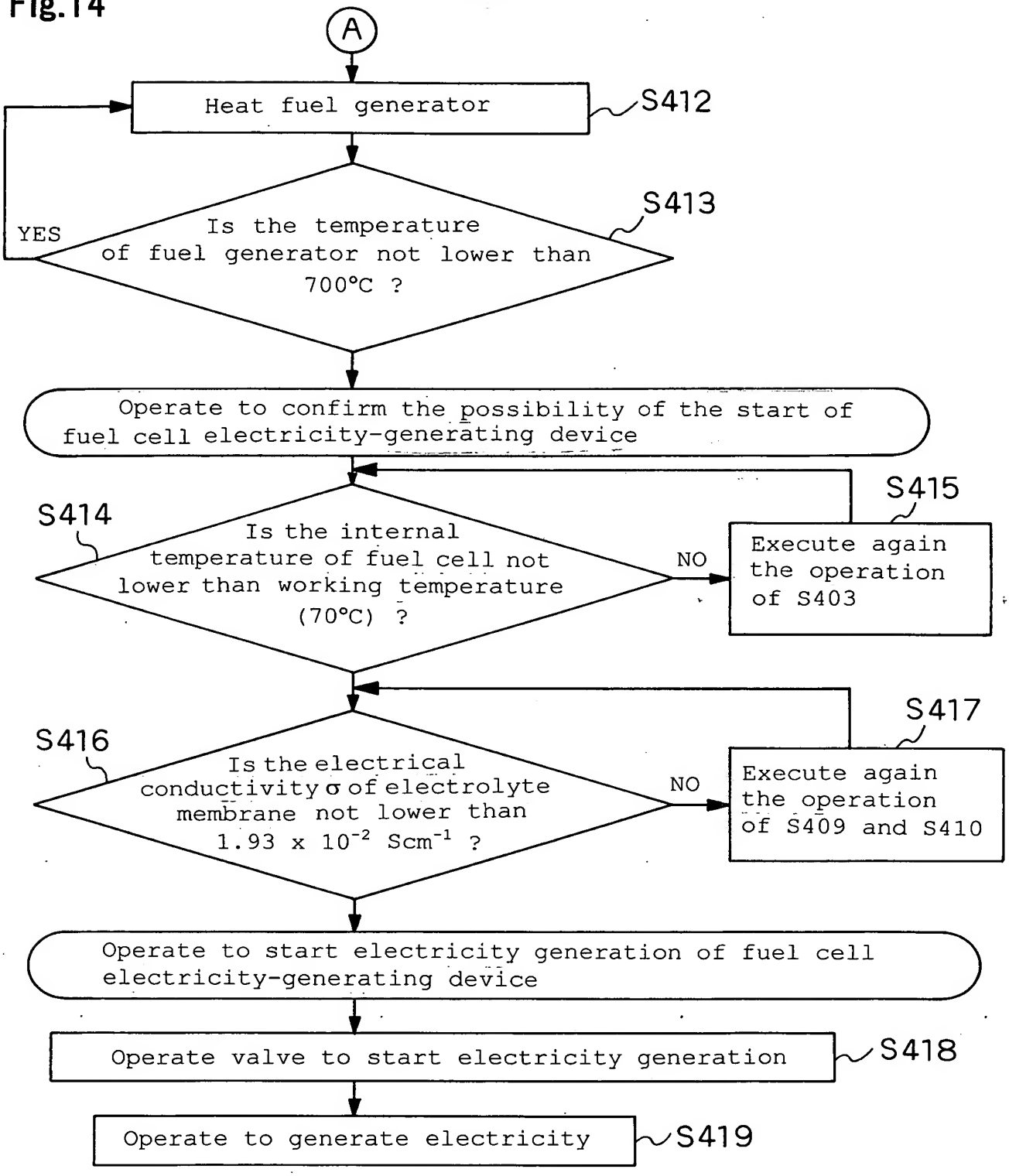

Operate to suspend and store fuel cell electricity-generating device
Operate valve for suspension and storage
S401
Operate to start fuel cell electricity-generating device
Select raw material gas and purify raw material gas
S402
Raise the internal temperature of fuel cell
S403
Is the internal temperature of fuel cell not lower than working temperature (70°C) ?
S404
NO
YES
Operate valve to preheat fuel generator
S405
Preheat fuel generator
S406
Did the temperature of fuel generator reach a range of 250°C to 300°C ?
S407
NO
YES
Render the interior of fuel generator moistenable with raw material gas
S408
Operate valve to supply moistened raw material gas to fuel cell
S409
Supply predetermined amount of moistened raw material gas to fuel cell
S410
Operate valve to heat fuel generator
S411
A

Fig.14


A
Heat fuel generator
S412
S413
YES
Is the temperature of fuel generator not lower than 700°C ?
Operate to confirm the possibility of the start of fuel cell electricity-generating device
S414
Is the internal temperature of fuel cell not lower than working temperature (70°C) ?
NO
S415
Execute again the operation of S403
S416
Is the electrical conductivity σ of electrolyte membrane not lower than 1.93 x 10-2 Scm-1 ?
NO
S417
Execute again the operation of S409 and S410
Operate to start electricity generation of fuel cell electricity-generating device
Operate valve to start electricity generation
S418
Operate to generate electricity
S419

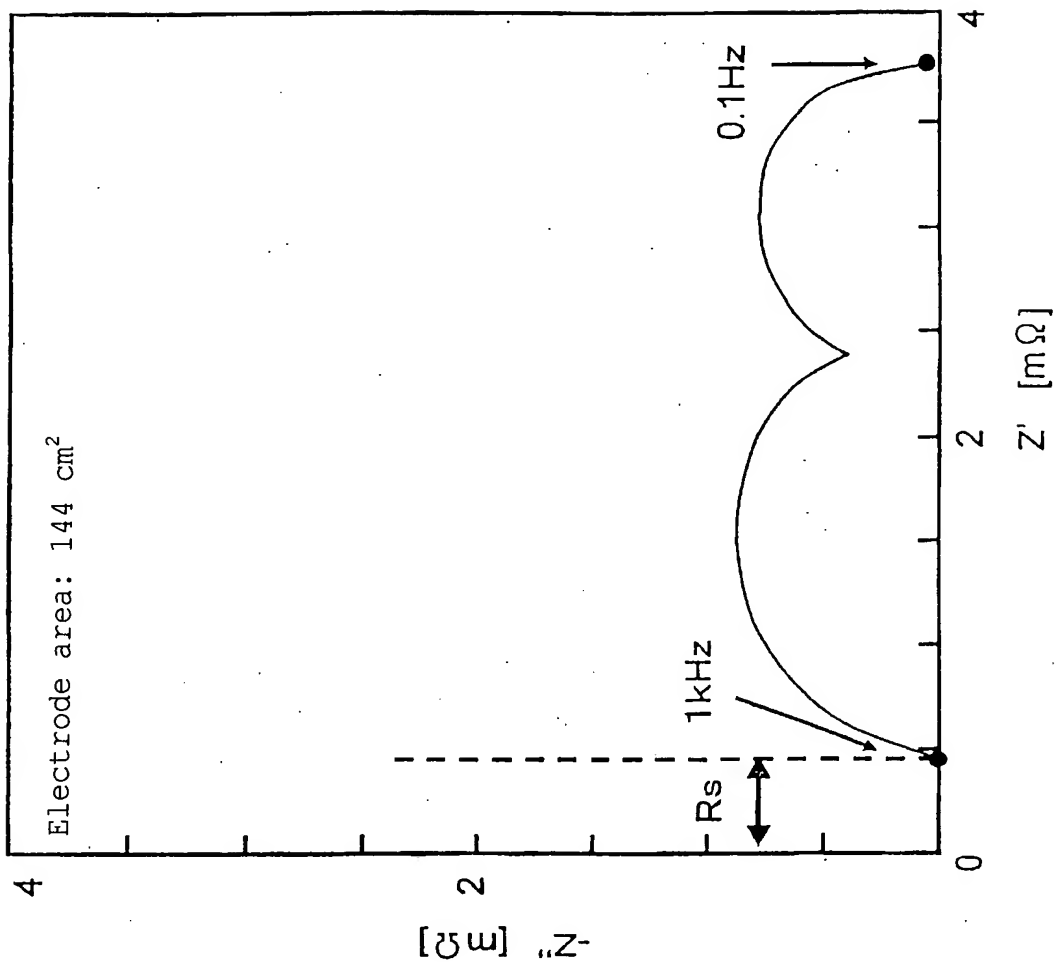
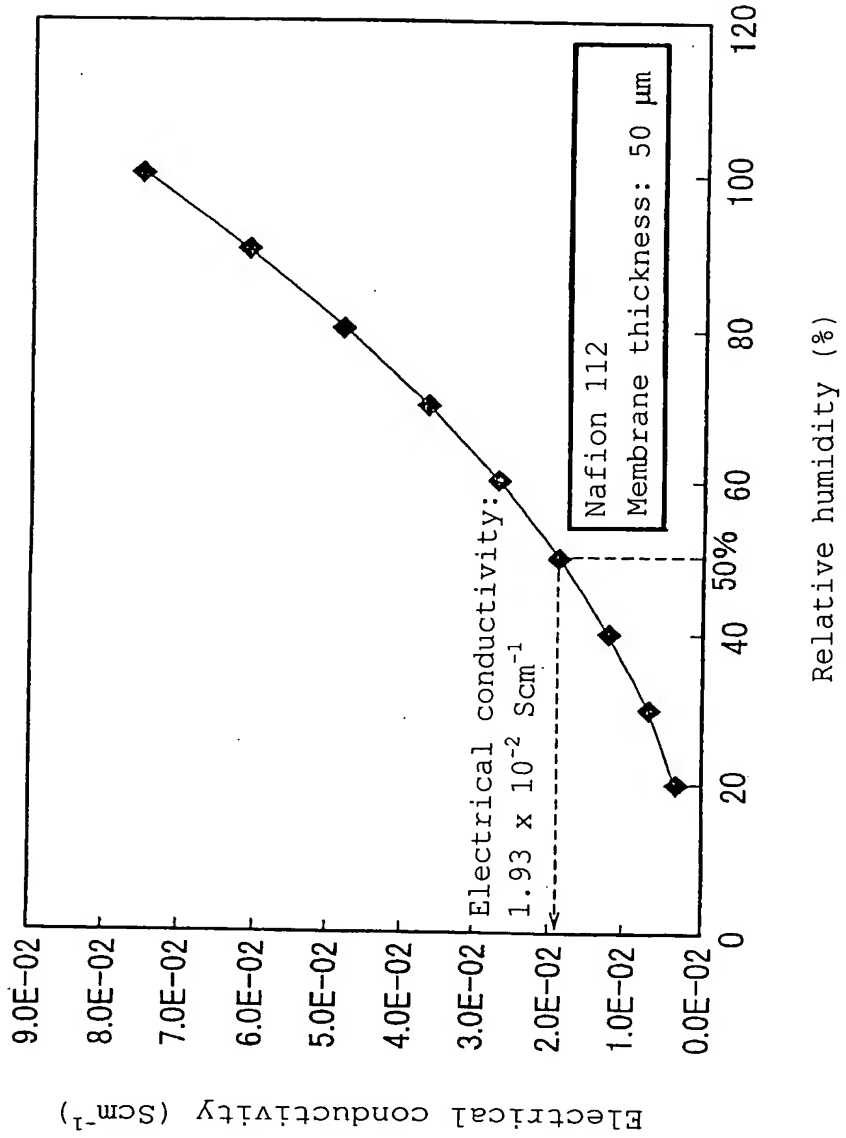


Fig.15

Fig.16


Electrical conductivity (Scm-1)
9.0E-02
8.0E-02
7.0E-02
6.0E-02
5.0E-02
4.0E-02
3.0E-02
2.0E-02
1.0E-02
0.0E-02
0
20
40
50%
60
80
100
120
Relative humidity (%)
Electrical conductivity:
1.93 x 10-2 Scm-1
Nafion 112
Membrane thickness: 50 µm

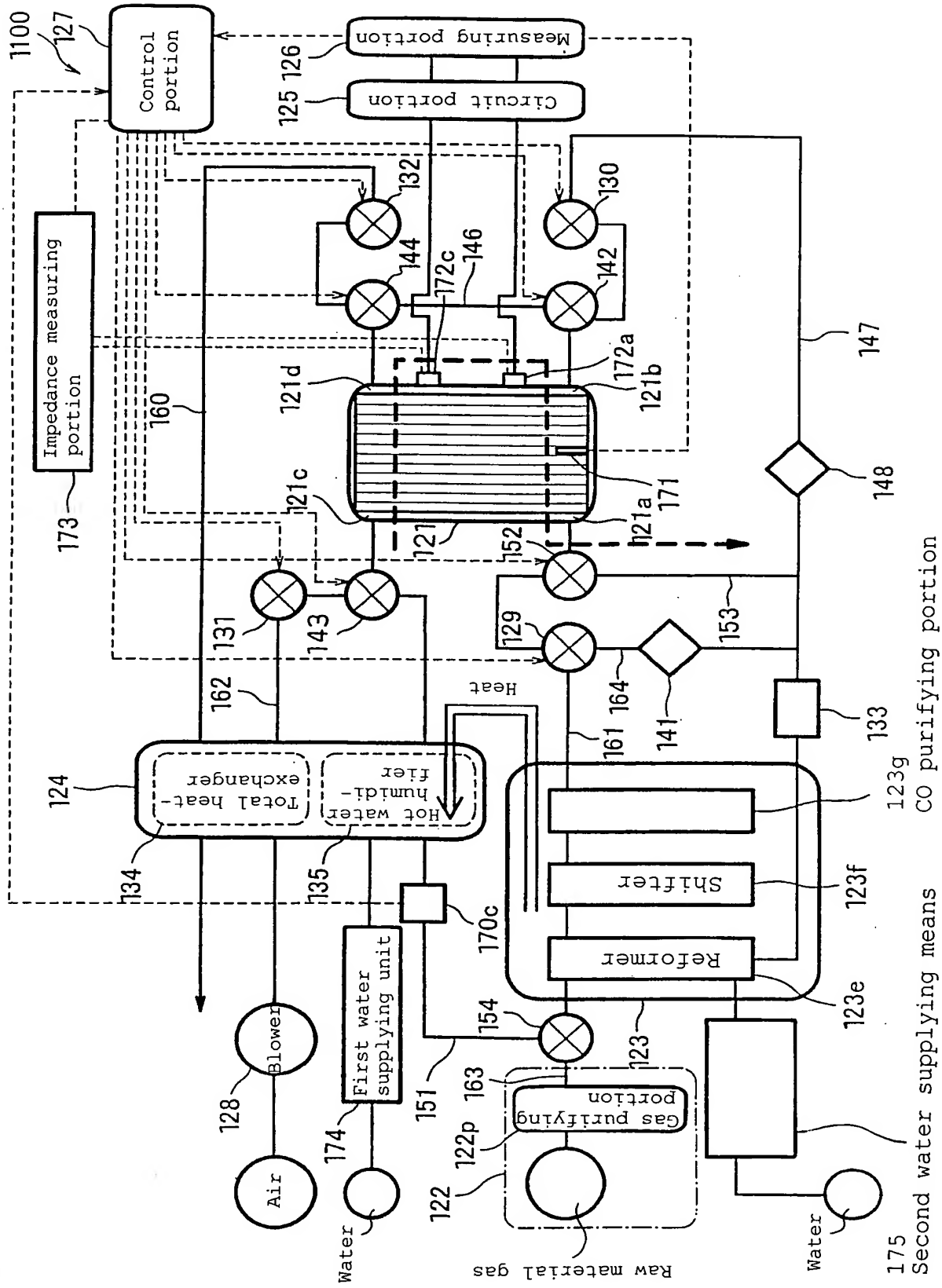

1100
127
Control portion
125 126
Measuring portion
Circuit portion
Impedance measuring portion
173
160
132
130
144
172c
146
142
172a
121d
121b
147
148
171
121c
121a
121
152
153
131
143
129
162
164
141
161
133
Heat
124
Total heat-exchanger
Hot water humidi-fier
134
135
170c
123g
CO purifying portion
Shifter
123f
Reformer
123e
154
123
151
163
Gas purifying portion
122p
122
128
Blower
Air
174
First water supplying unit
Water
Raw material gas
Water
175
Second water supplying means

Fig.17

Fig.18

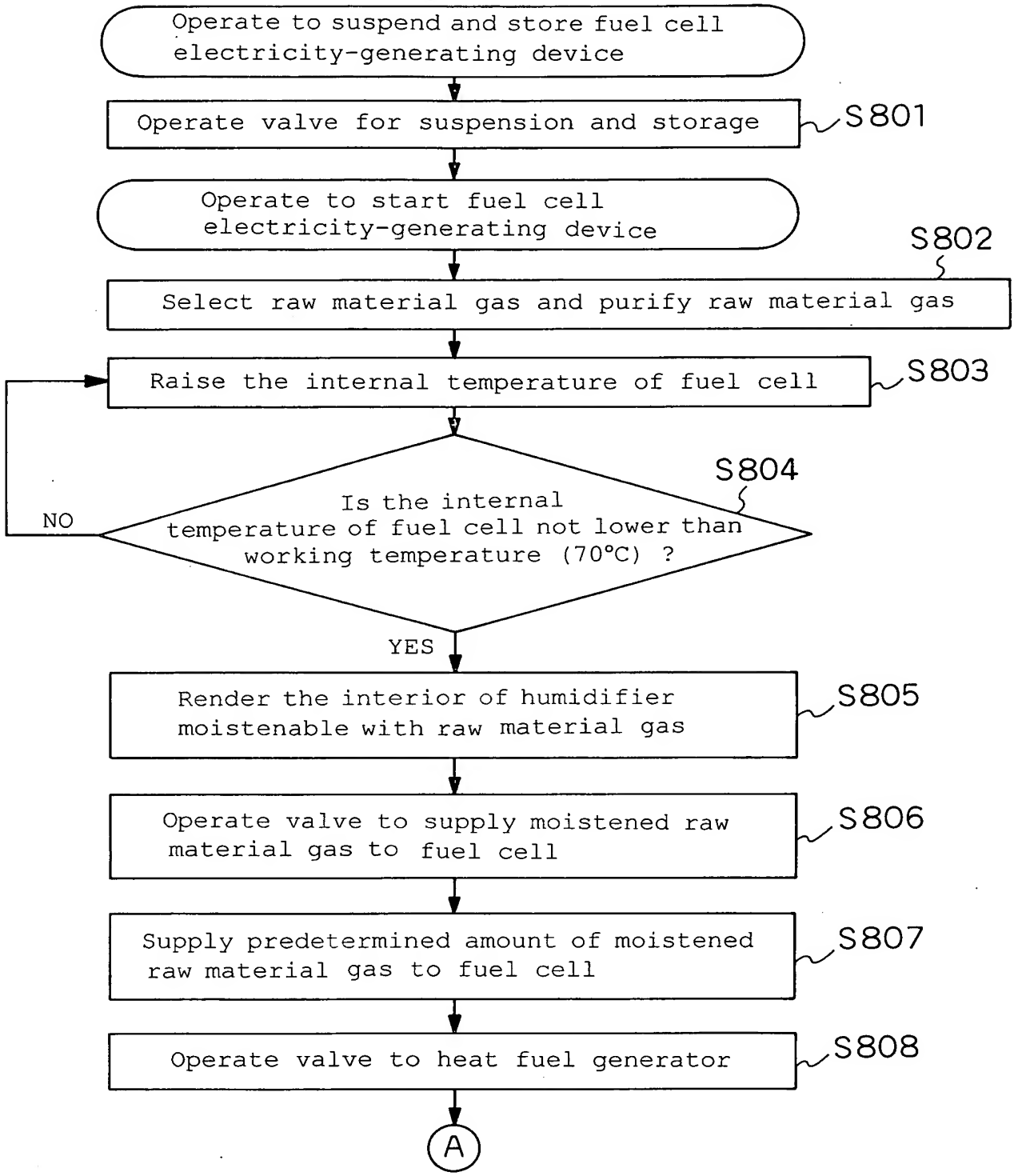

Operate to suspend and store fuel cell electricity-generating device
Operate valve for suspension and storage
S801
Operate to start fuel cell electricity-generating device
S802
Select raw material gas and purify raw material gas
Raise the internal temperature of fuel cell
S803
S804
Is the internal temperature of fuel cell not lower than working temperature (70°C) ?
NO
YES
Render the interior of humidifier moistenable with raw material gas
S805
Operate valve to supply moistened raw material gas to fuel cell
S806
Supply predetermined amount of moistened raw material gas to fuel cell
S807
Operate valve to heat fuel generator
S808
A

Fig.19

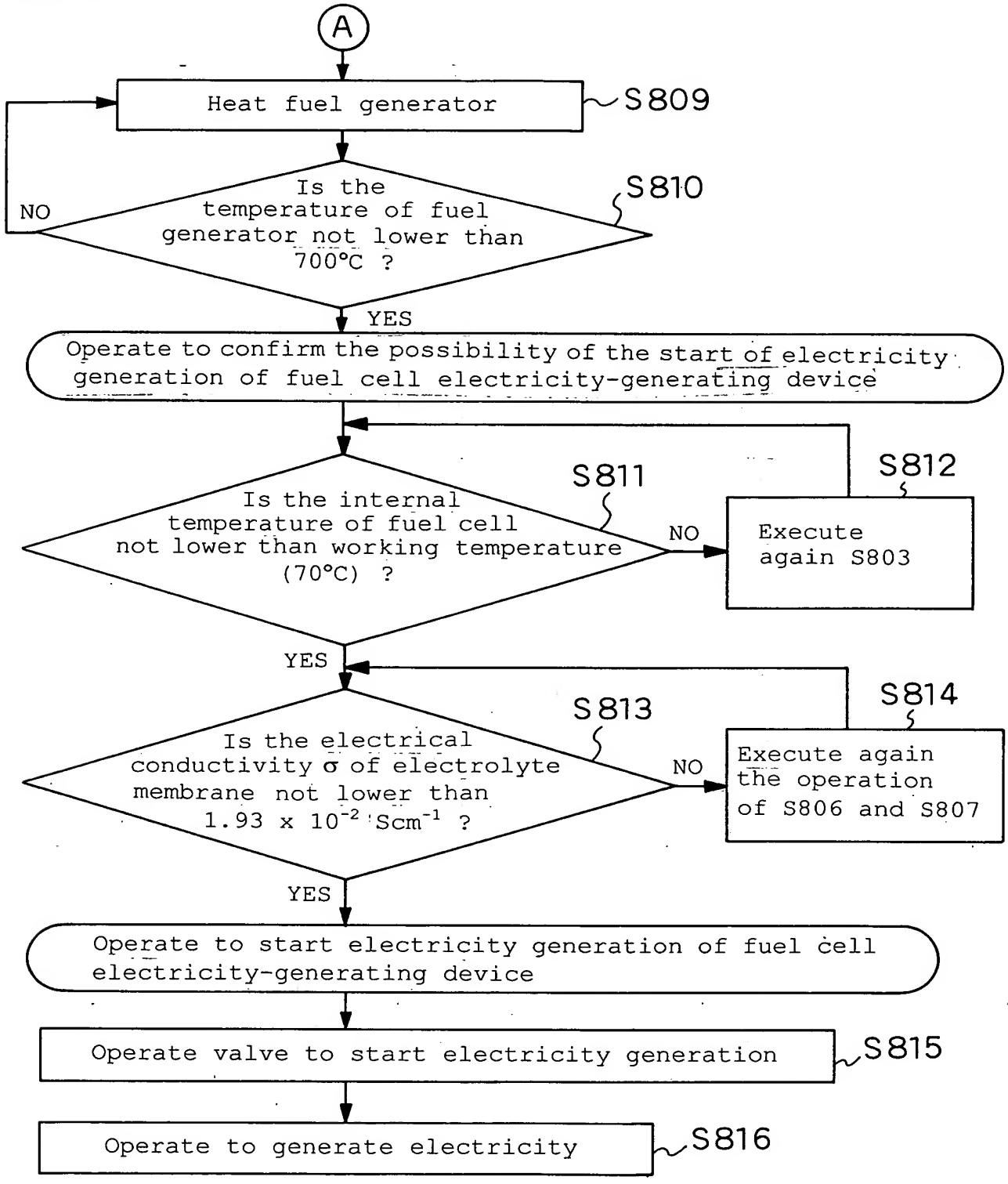

A
Heat fuel generator
S809
Is the temperature of fuel generator not lower than 700°C ?
S810
NO
YES
Operate to confirm the possibility of the start of electricity generation of fuel cell electricity-generating device
Is the internal temperature of fuel cell not lower than working temperature (70°C) ?
S811
NO
Execute again S803
S812
YES
Is the electrical conductivity σ of electrolyte membrane not lower than 1.93×10^{-2} Scm^{-1} ?
S813
NO
Execute again the operation of S806 and S807
S814
YES
Operate to start electricity generation of fuel cell electricity-generating device
Operate valve to start electricity generation
S815
Operate to generate electricity
S816

Fig.20

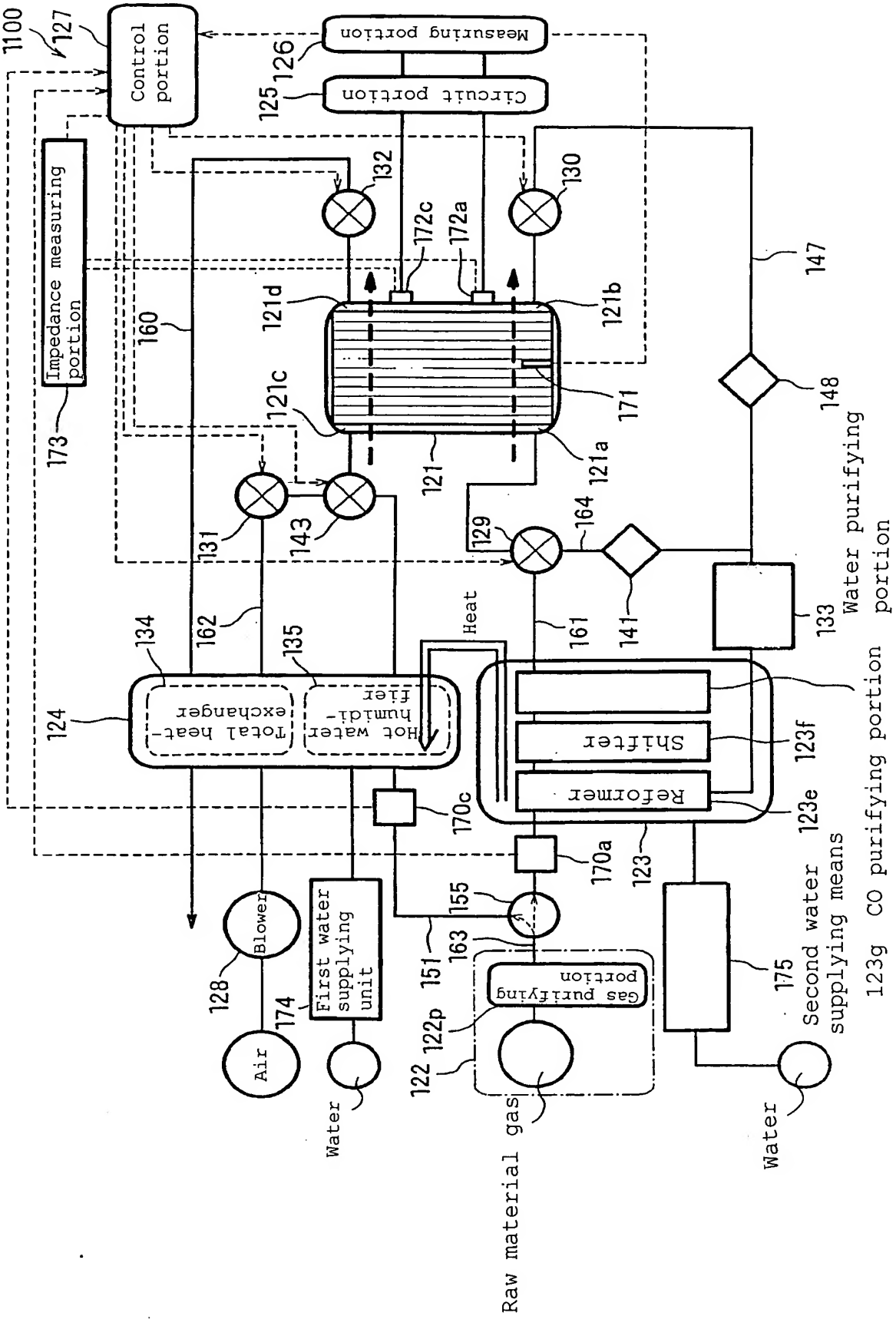

1100
127
Control portion
Measuring portion
126
125
Circuit portion
Impedance measuring portion
173
160
132
130
172c
172a
147
121d
121b
121c
171
148
121a
121
131
143
129
164
Heat
161
141
133
Water purifying portion
134
162
135
124
Total heat-exchanger
Hot water humidi-fier
Shifter
123f
Reformer
123e
170c
170a
123
155
163
151
Blower
128
First water supplying unit
174
Gas purifying portion
122p
122
Air
Water
Raw material gas
175
Second water supplying means
123g CO purifying portion
Water

Fig.21

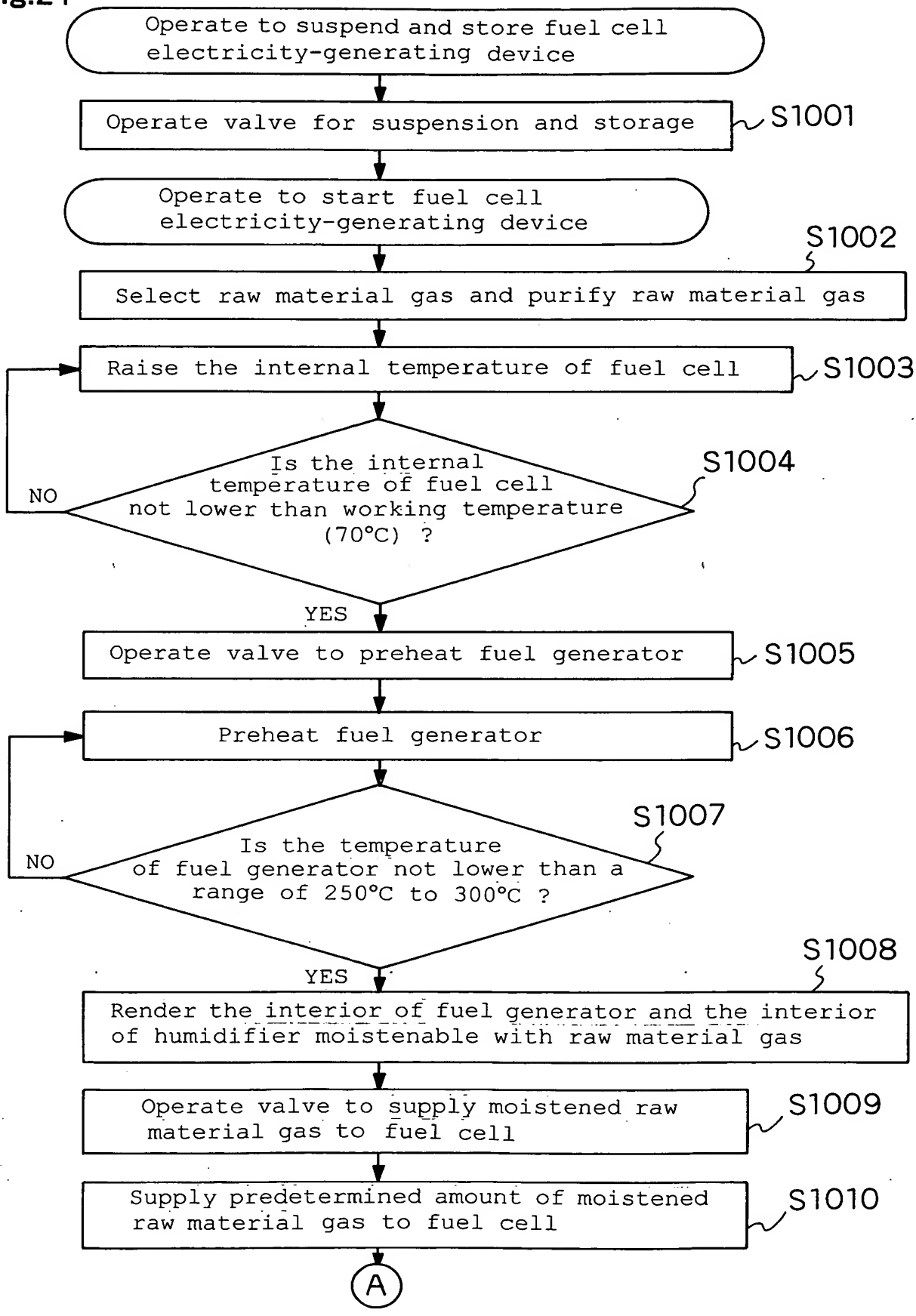

Operate to suspend and store fuel cell electricity-generating device
Operate valve for suspension and storage
S1001
Operate to start fuel cell electricity-generating device
S1002
Select raw material gas and purify raw material gas
Raise the internal temperature of fuel cell
S1003
Is the internal temperature of fuel cell not lower than working temperature (70°C) ?
S1004
NO
YES
Operate valve to preheat fuel generator
S1005
Preheat fuel generator
S1006
Is the temperature of fuel generator not lower than a range of 250°C to 300°C ?
S1007
NO
YES
S1008
Render the interior of fuel generator and the interior of humidifier moistenable with raw material gas
Operate valve to supply moistened raw material gas to fuel cell
S1009
Supply predetermined amount of moistened raw material gas to fuel cell
S1010
A

Fig.22

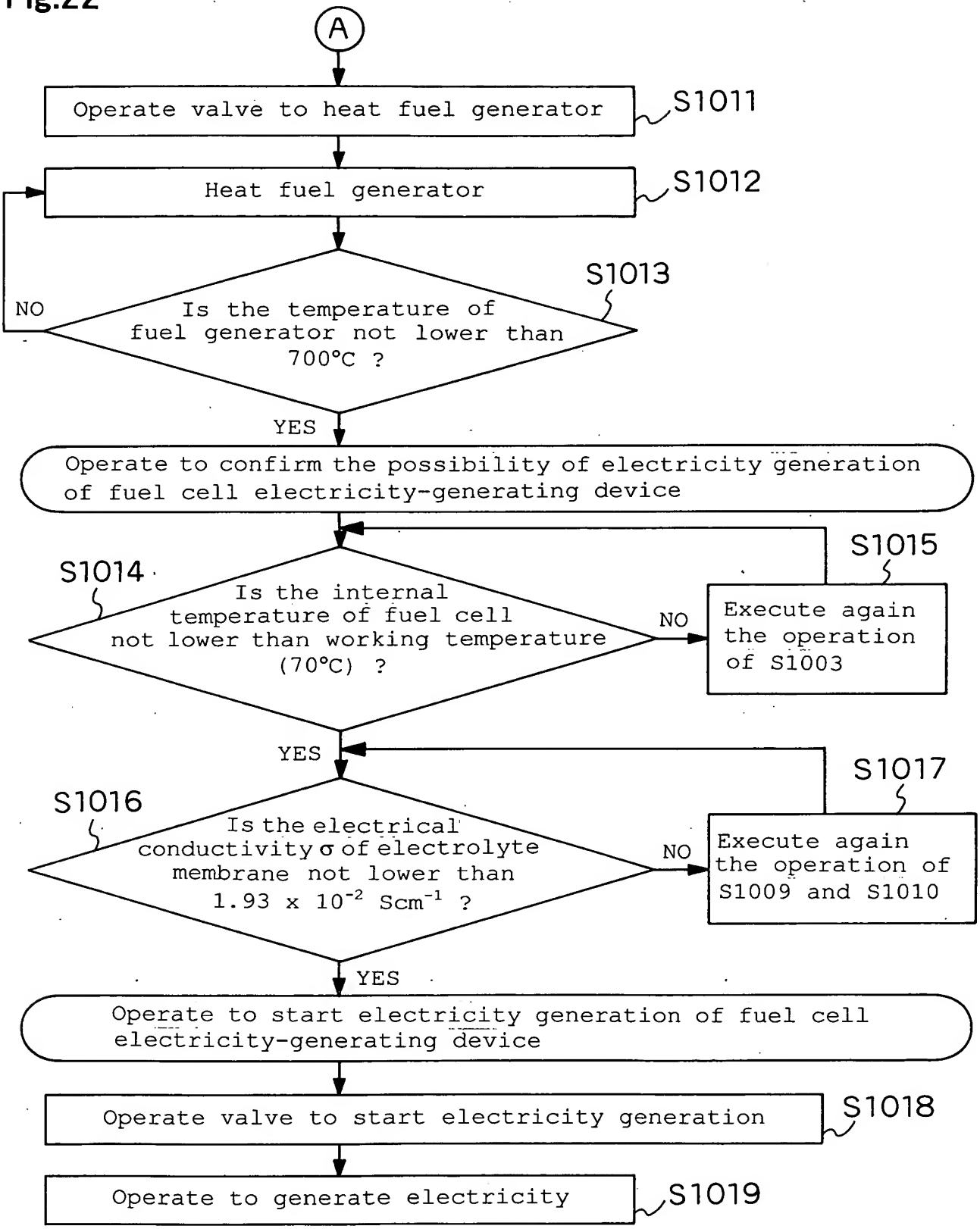

A
Operate valve to heat fuel generator
S1011
Heat fuel generator
S1012
S1013
NO
Is the temperature of fuel generator not lower than 700°C ?
YES
Operate to confirm the possibility of electricity generation of fuel cell electricity-generating device
S1015
S1014
Is the internal temperature of fuel cell not lower than working temperature (70°C) ?
NO
Execute again the operation of S1003
YES
S1017
S1016
Is the electrical conductivity σ of electrolyte membrane not lower than 1.93 x 10-2 Scm-1 ?
NO
Execute again the operation of S1009 and S1010
YES
Operate to start electricity generation of fuel cell electricity-generating device
Operate valve to start electricity generation
S1018
Operate to generate electricity
S1019

Fig.23

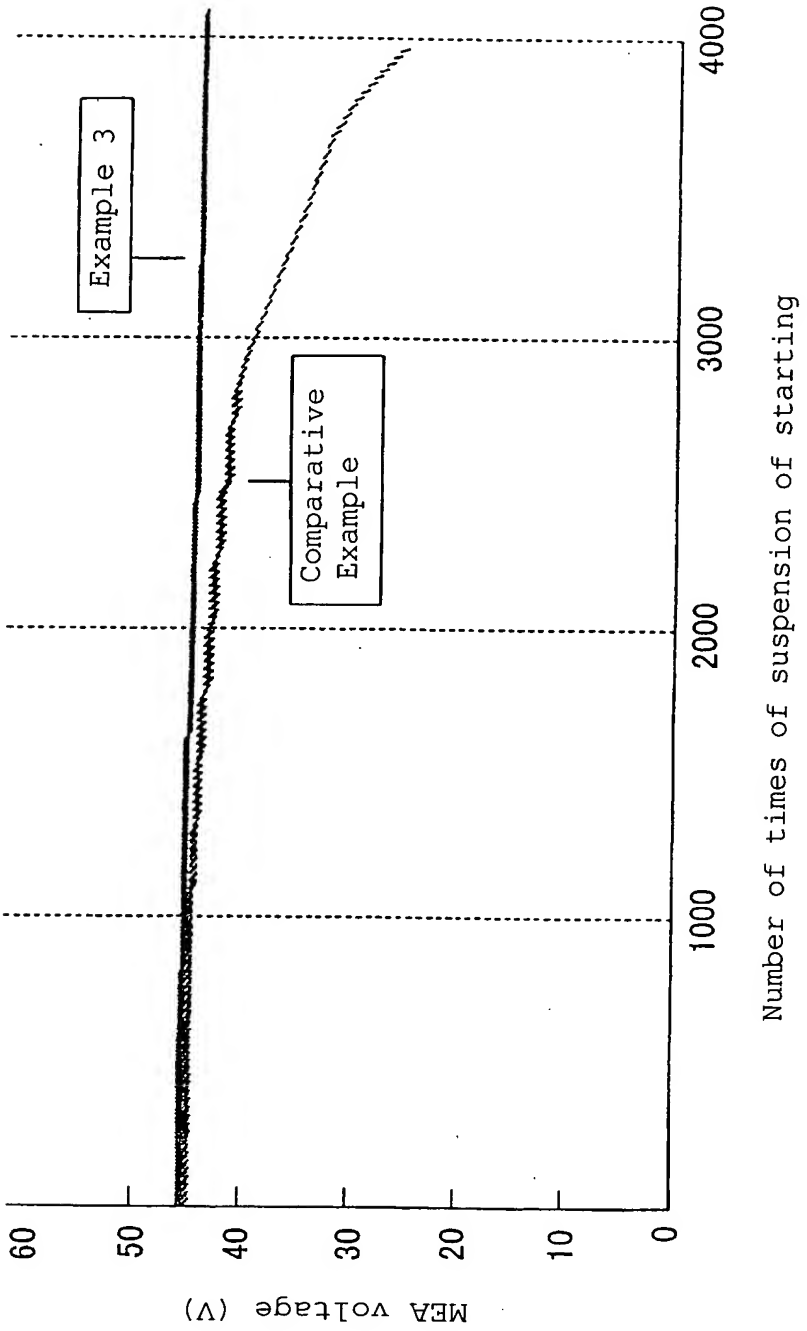

MEA voltage (V)
60
50
40
30
20
10
0
1000
2000
3000
4000
Number of times of suspension of starting
Example 3
Comparative Example

Fig.24

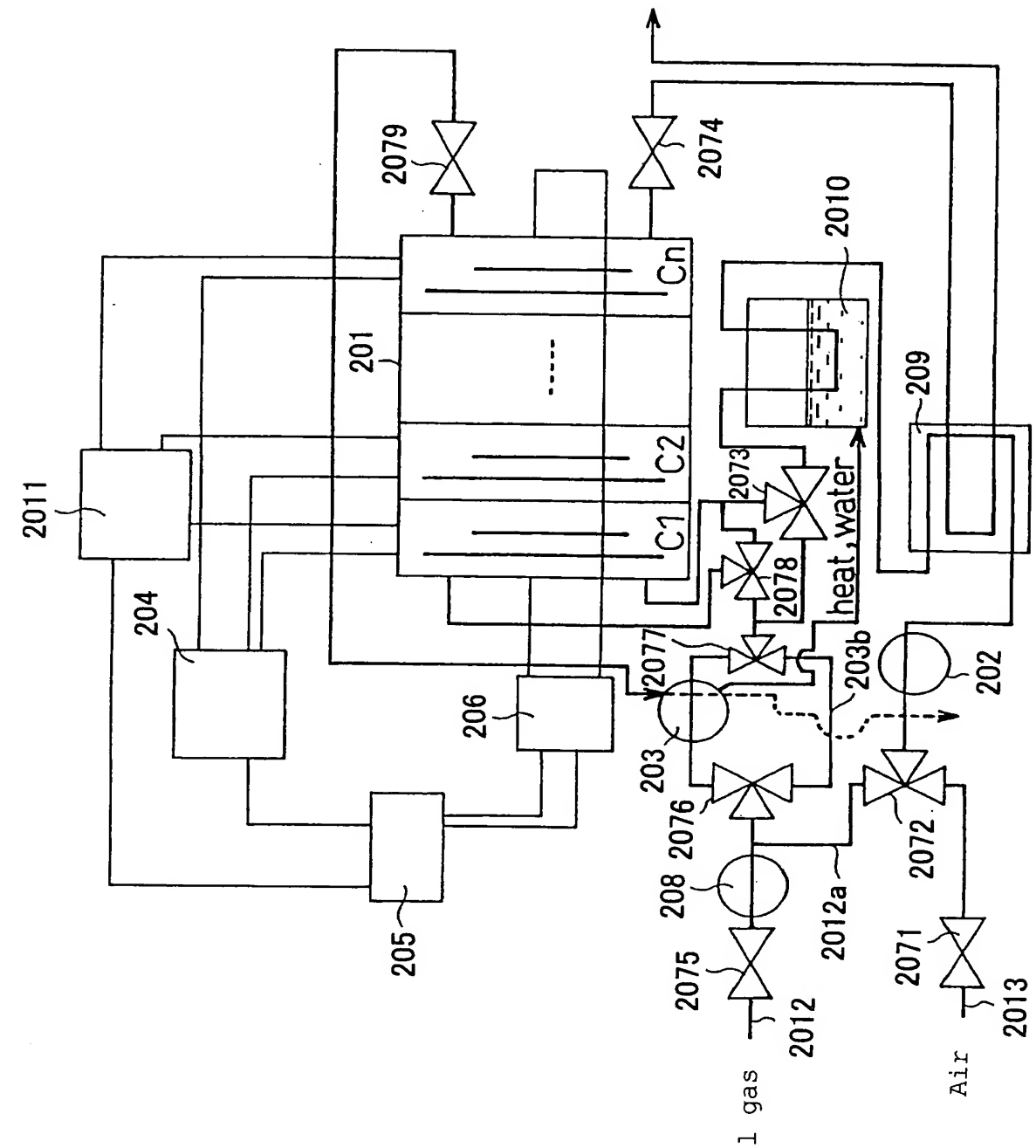

2011
204
205
206
201
Cn
C2
C1
2079
2074
2010
209
2073
heat, water
2078
2077
203b
202
203
2076
208
2072
2012a
2075
2071
2012
2013
Raw material gas
Air

Fig.25

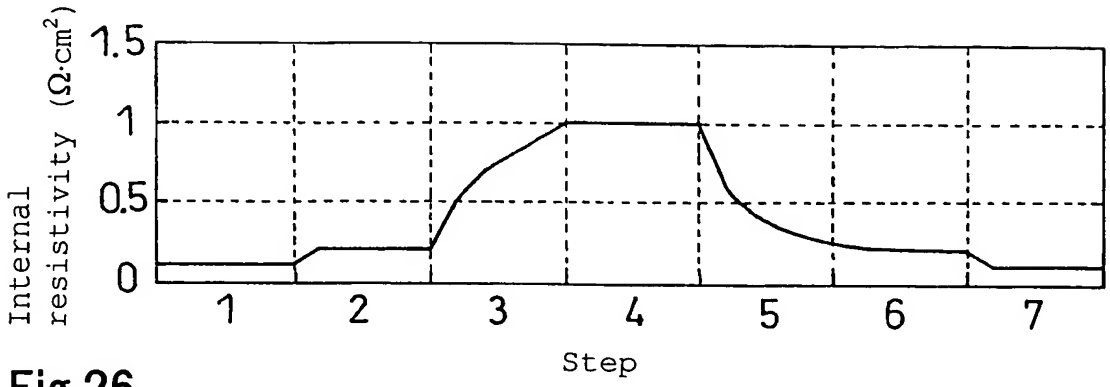


Fig.26

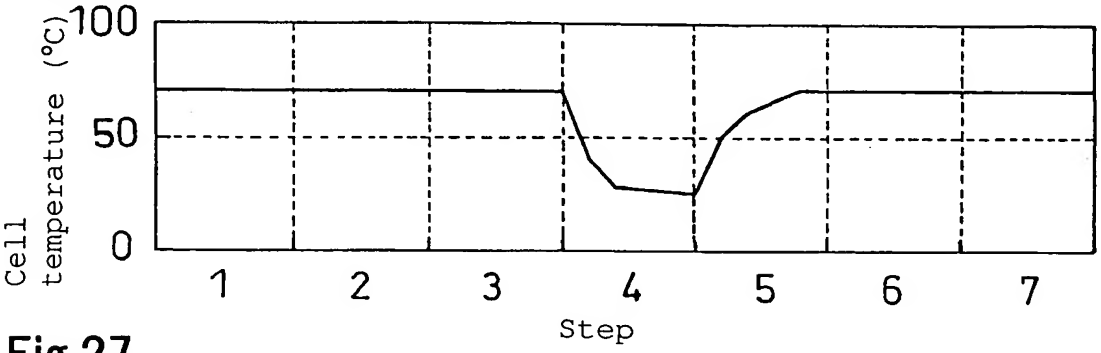


Fig.27

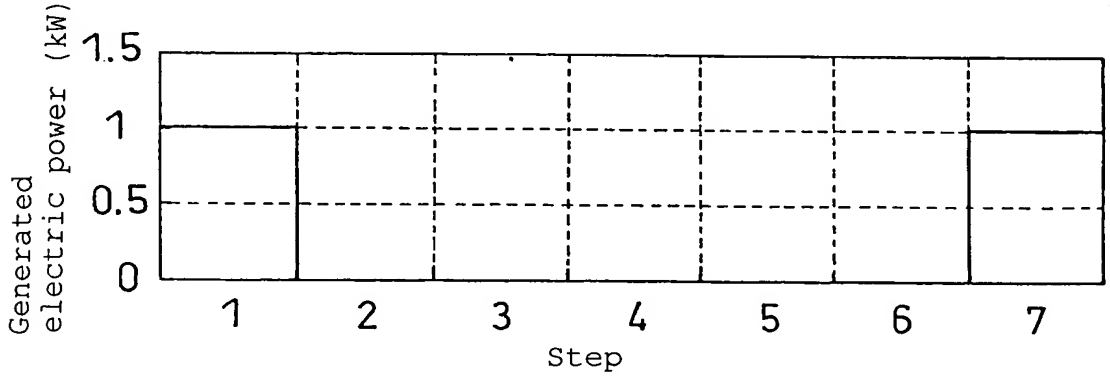


Fig.28

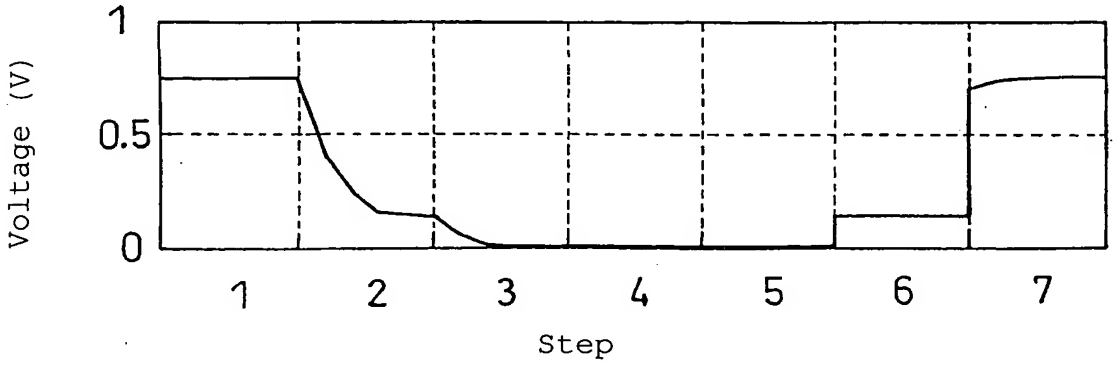


Fig.29

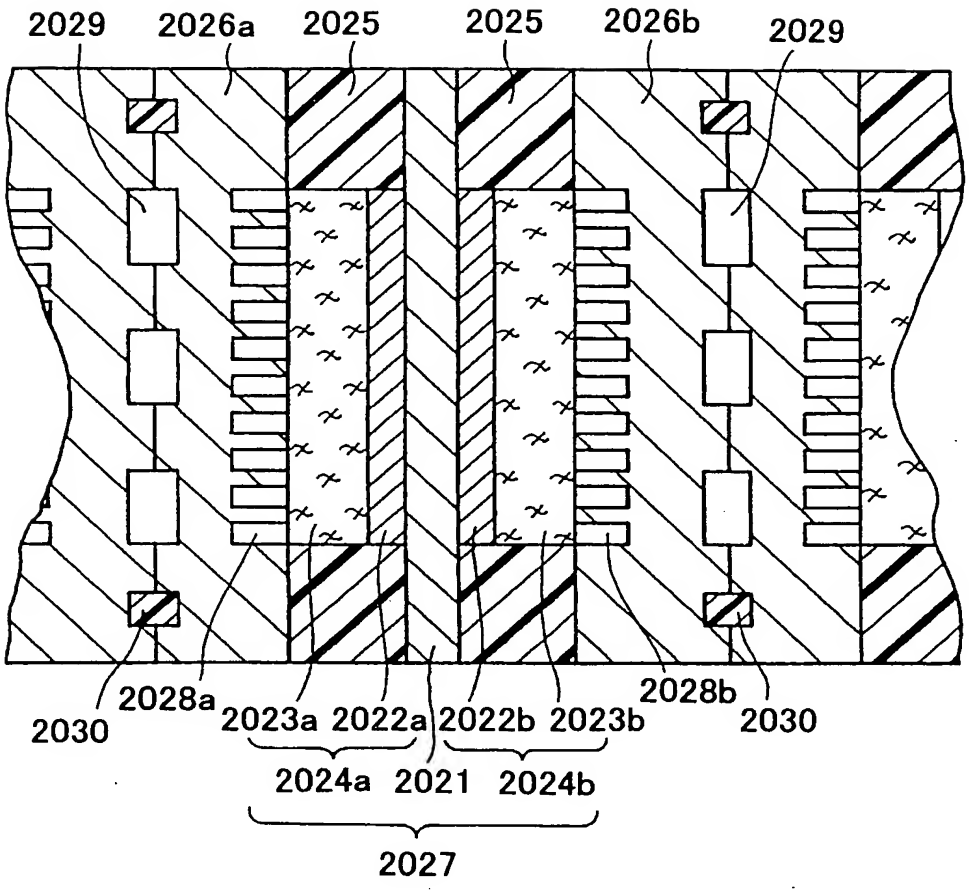
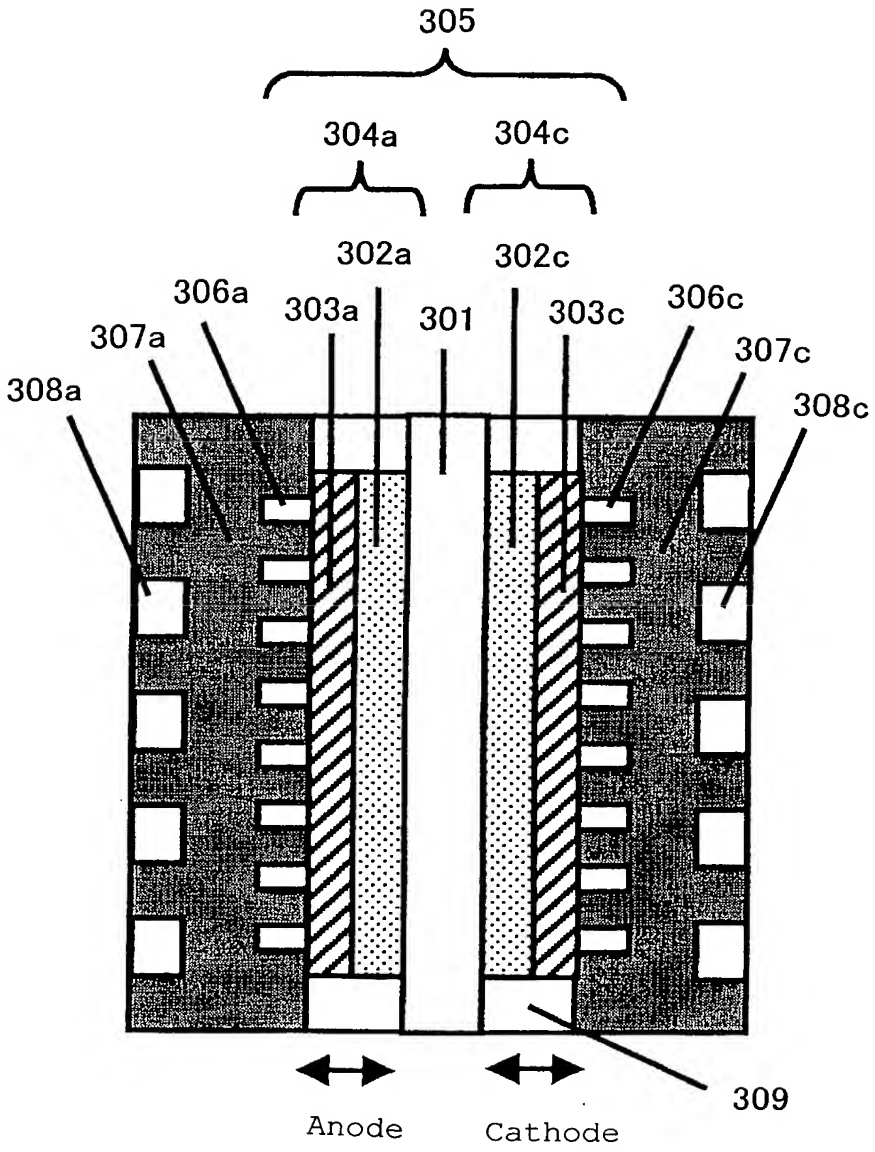
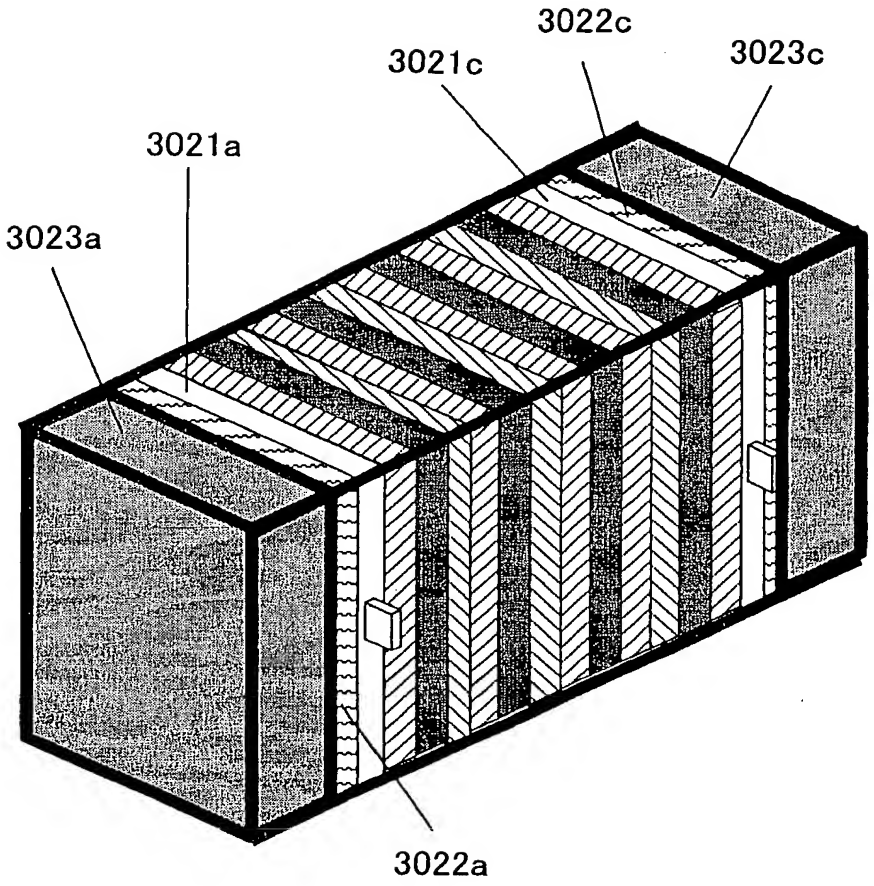

2029
2026a
2025
2025
2026b
2029
2028a
2030
2023a
2022a
2022b
2023b
2028b
2030
2024a
2021
2024b
2027

Fig.30



BEST AVAILABLE COPY

Fig.31



BEST AVAILABLE COPY

Fig.32

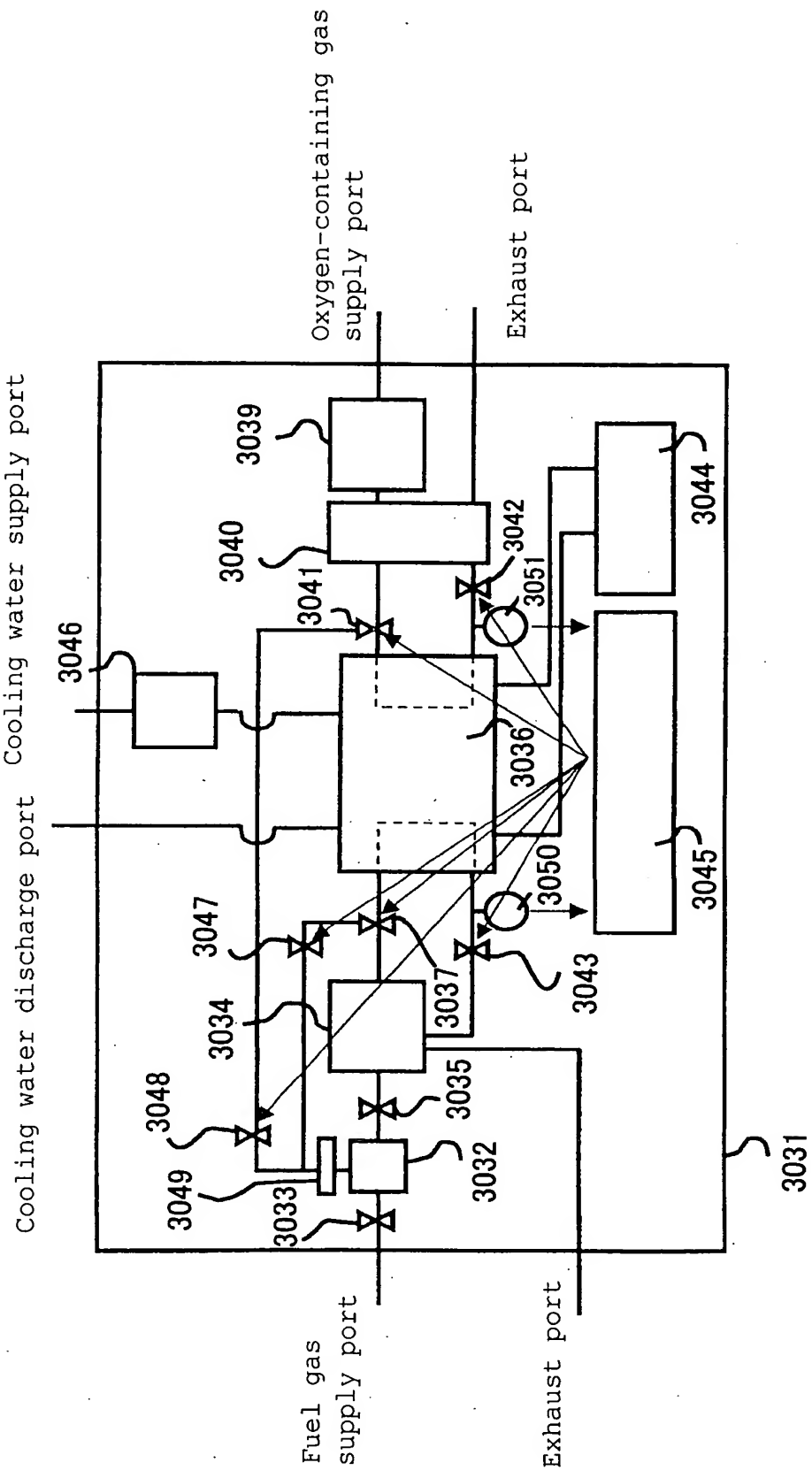
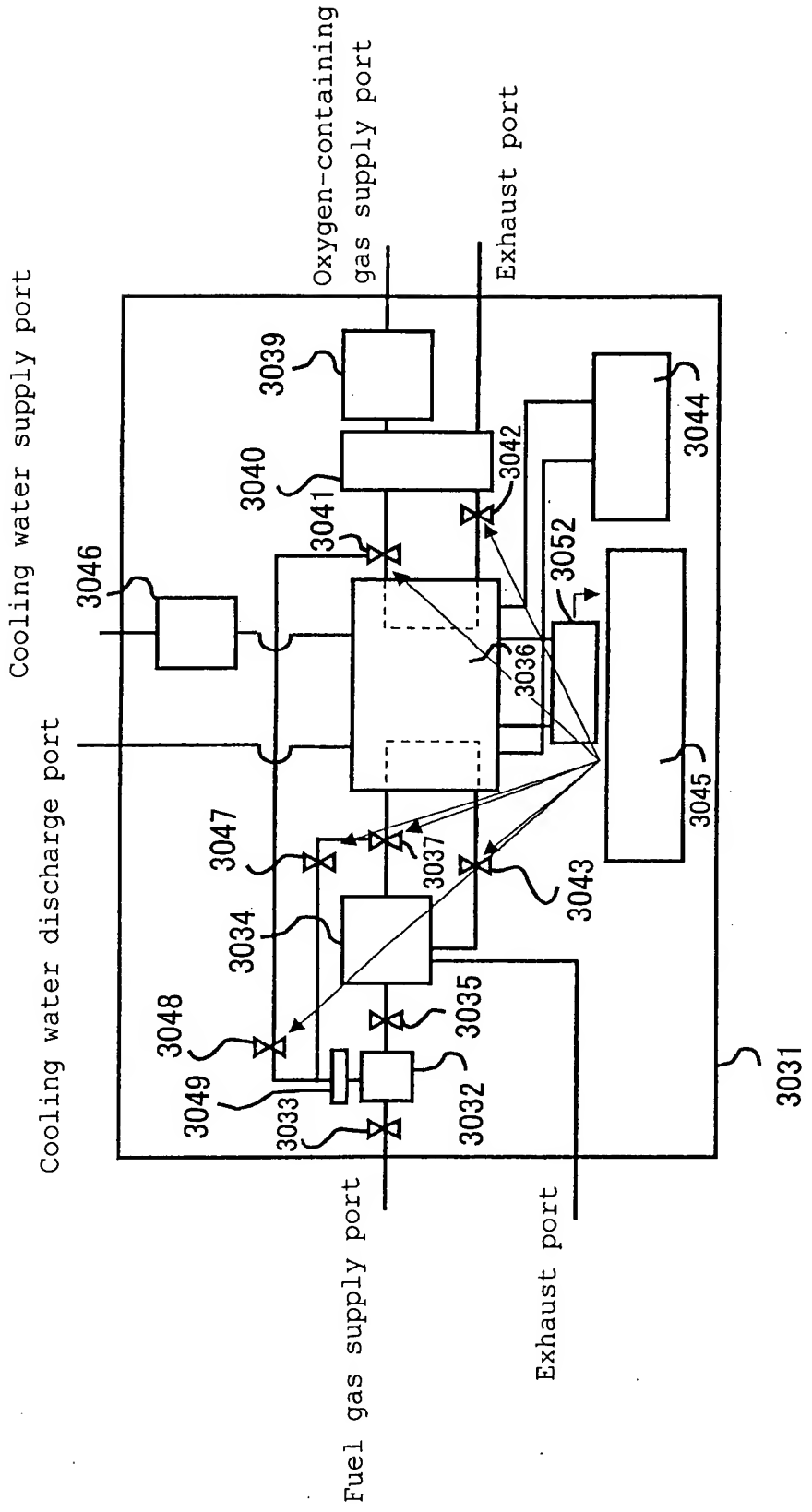

Oxygen-containing gas supply port
Exhaust port
Cooling water supply port
Cooling water discharge port
Fuel gas supply port
Exhaust port
3031
3032
3033
3034
3035
3036
3037
3039
3040
3041
3042
3043
3044
3045
3046
3047
3048
3049
3050
3051

Fig.33


Cooling water supply port
Oxygen-containing gas supply port
Exhaust port
Cooling water discharge port
Fuel gas supply port
Exhaust port
3031
3032
3033
3034
3035
3036
3037
3039
3040
3041
3042
3043
3044
3045
3046
3047
3048
3049
3052

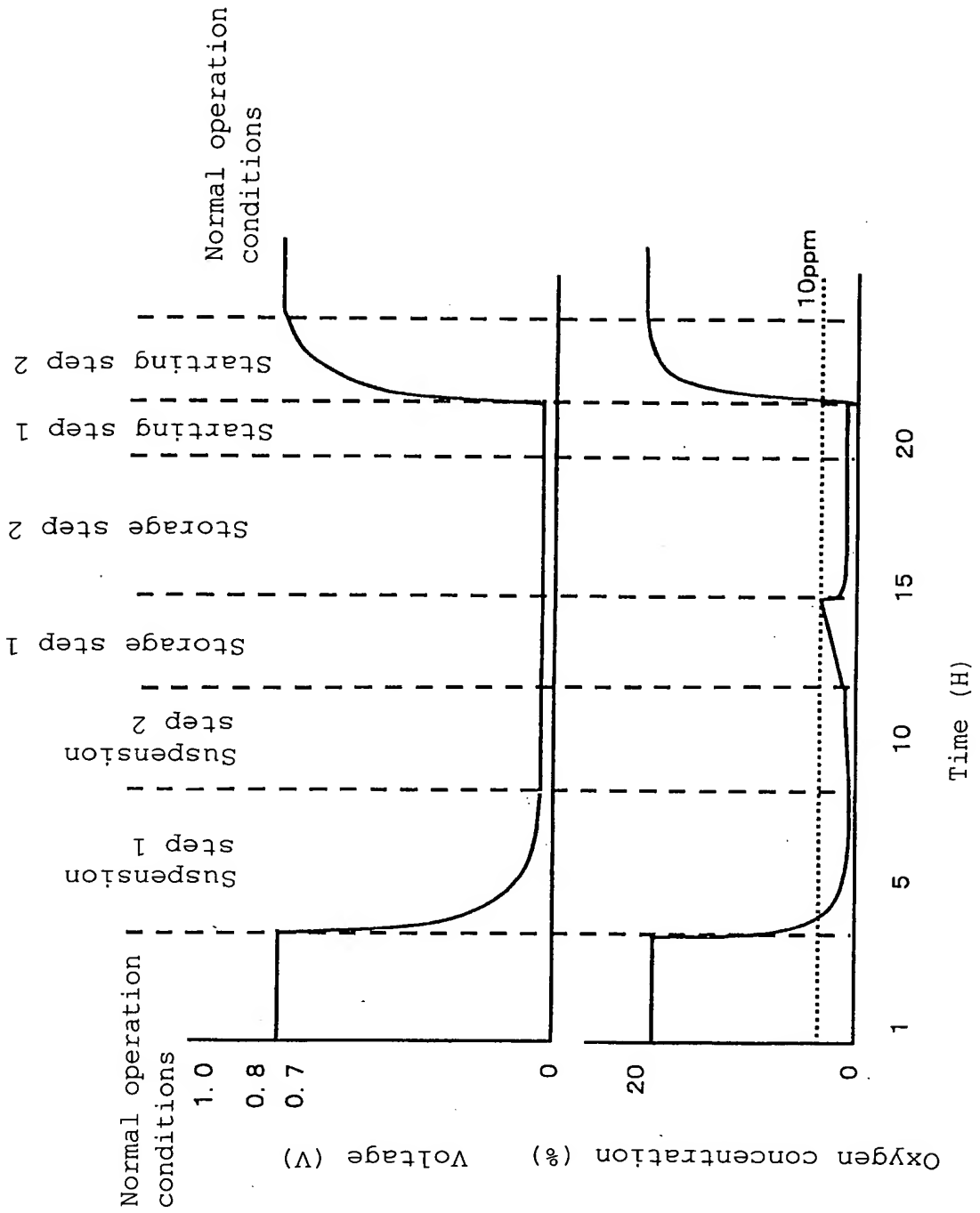

Normal operation conditions
Starting step 2
Starting step 1
Storage step 2
Storage step 1
Suspension step 2
Suspension step 1
Normal operation conditions
1.0
0.8
0.7
0
20
0
10ppm
1
5
10
15
20
Time (H)
Voltage (V)
Oxygen concentration (%)

Fig.34

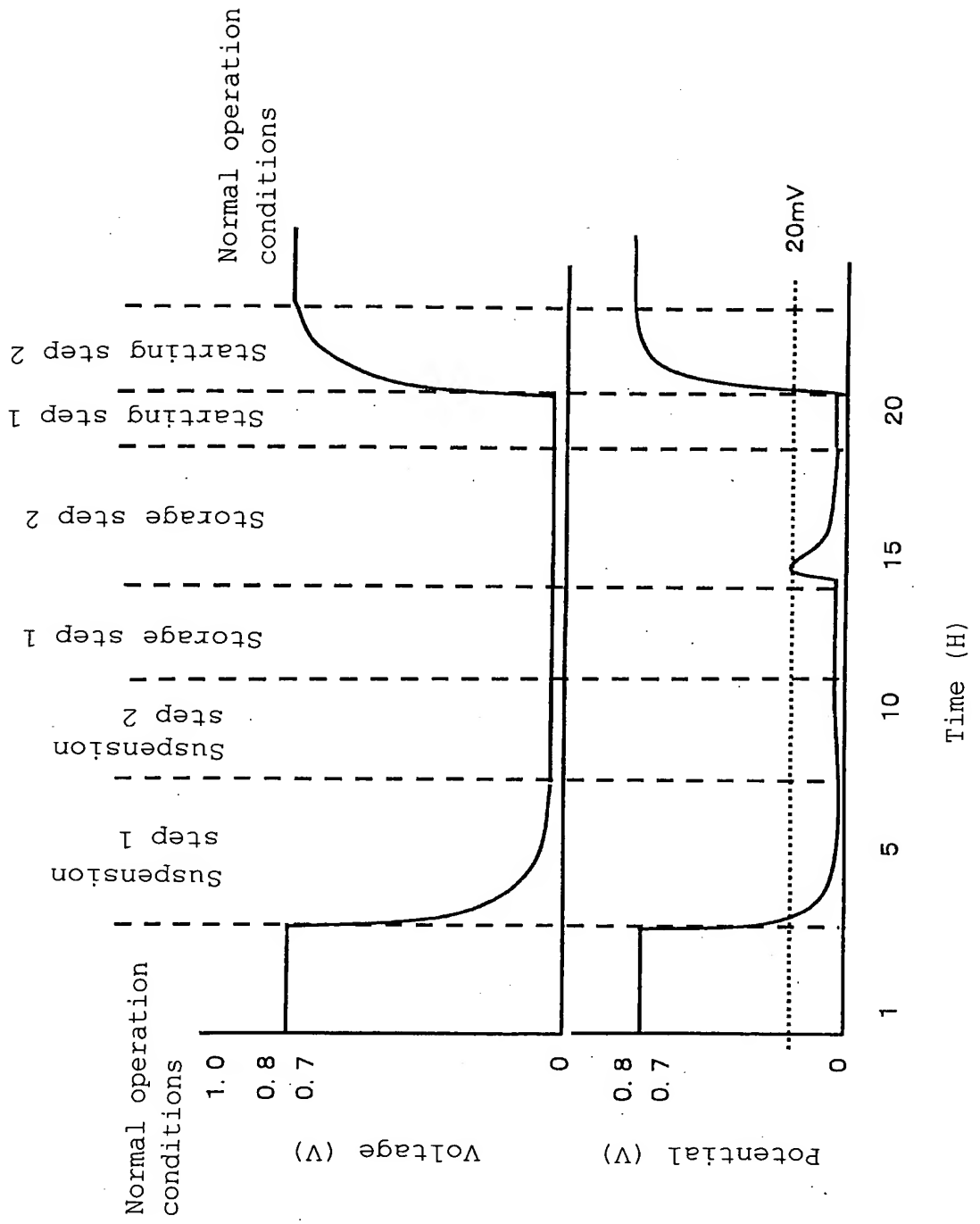

Normal operation conditions
Starting step 2
Starting step 1
Storage step 2
Storage step 1
Suspension step 2
Suspension step 1
Normal operation conditions
1.0
0.8
0.7
0
Voltage (V)
0.8
0.7
0
Potential (V)
20mV
1
5
10
15
20
Time (H)

Fig.35

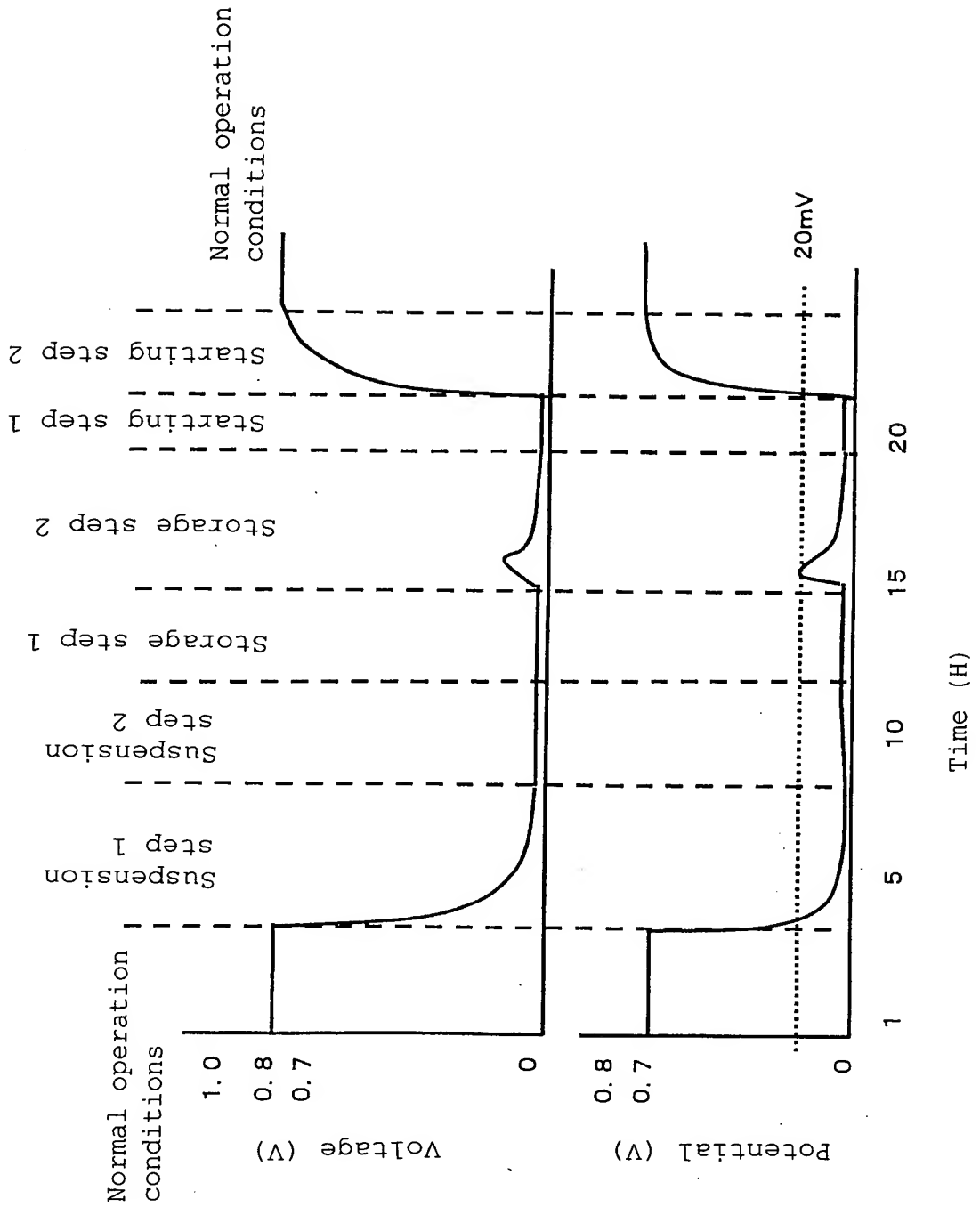
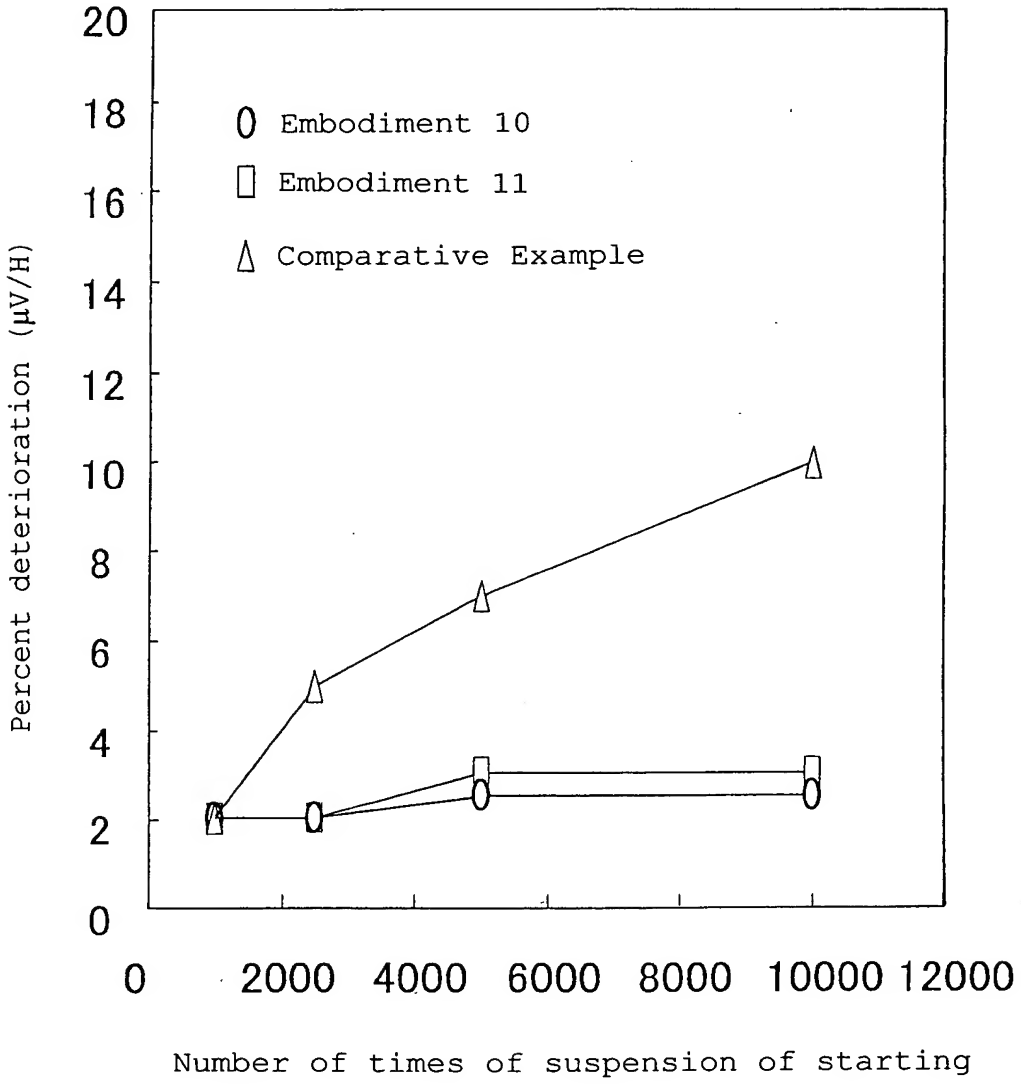

Normal operation conditions
Starting step 2
Starting step 1
Storage step 2
Storage step 1
Suspension step 2
Suspension step 1
Normal operation conditions
1.0
0.8
0.7
0
Voltage (V)
0.8
0.7
0
Potential (V)
20mV
1
5
10
15
20
Time (H)

Fig.36

Fig.37


20
18
16
14
12
10
8
6
4
2
0
Percent deterioration (μV/H)
Embodiment 10
Embodiment 11
Comparative Example
0
2000
4000
6000
8000
10000
12000
Number of times of suspension of starting

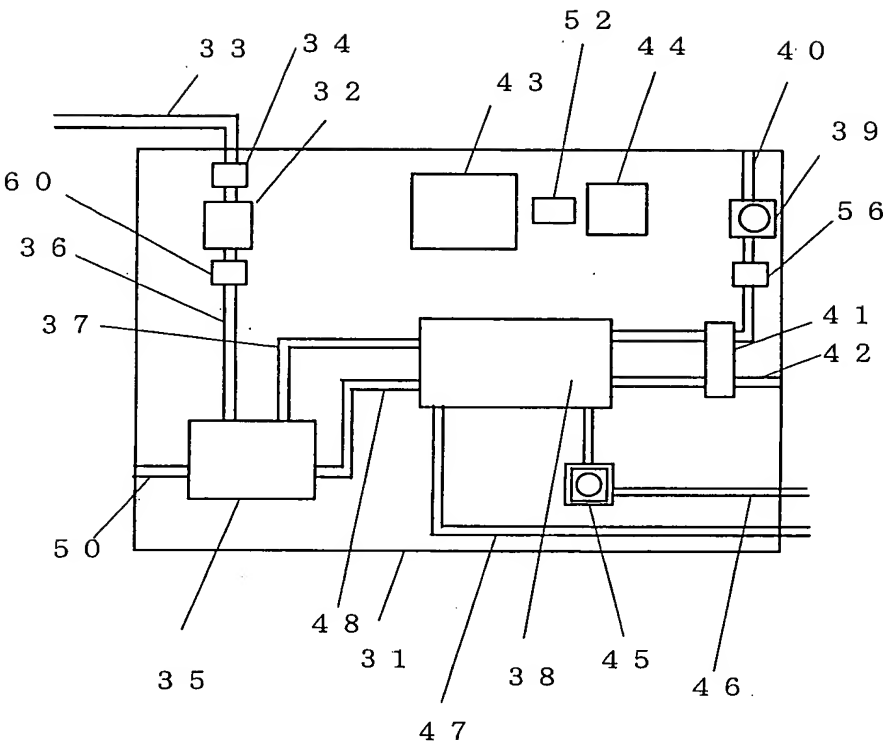



Fig.38